Silicon Institute of Technology
| An Autonomous Institute |

Curriculum Structure and Detailed Syllabus

Master of Technology in Electronics & Communication Engineering

Department of Electronics & Communication Engineering
Silicon Institute of Technology
Silicon Hills, Patia, Bhubaneswar - 751024

Effective from Academic Year 2018-19
Version: 1.20 (Build: 25-09-2020)

Approval History

ACM#	Date	Resolutions
AC-1	14/08/2018	The curriculum & detailed syllabus of 1st Year, as proposed by the Board of Studies, is provisionally approved by the Academic Council.
AC-2	11/05/2019	The curriculum & detailed syllabus up to 2nd Year, as proposed by the Board of Studies, is approved by the Academic Council.

Program Outcomes

Program Outcomes (POs) form a set of individually assessable outcomes that are the components indicative of the post-graduate's potential to acquire competence to practice at the appropriate level. The following POs have been defined for the M.Tech programmes in line with NBA, so that the outcomes can be assessed in a similar manner to UG Engineering programmes:

PO1. Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.

PO2. Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.

PO3. Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.

PO4. Understand and use different software tools for design, analysis and verification in the domain of communication, VLSI and signal processing through design, synthesis, functional, and timing simulation.

PO5. Design and conduct experiments, analyze and interpret data, utilize programming skills for development of simulation experiments.

PO6. Function effectively as an individual or as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.

PO7. Understand the impact of electronics & communications in an economic, social and environment context.

PO8. Understand intellectual property rights and overall professional & ethical responsibility.

PO9. Communicate effectively in a technically sound manner with a wide range of audience.

PO10. Continue to learn independently and engage in life-long learning.

Program Educational Objectives (PEOs)

PEO1. To imbibe technical skills to create, find solutions, and propose improvements for complex problems encountered in Electronics & Communication Engineering for betterment of society, mankind, and environment.

PEO2. To inculcate an attitude to adopt changing technologies in Electronics & Communication Engineering through critical observation, survey, experimentation, and research independently or collaboratively.

PEO3. To provide professional & intellectual integrity, motivation to engage in research & development, and communicate innovative ideas effectively for advancement of society.

Program Specific Outcomes (PSOs)

PSO1. Apply concepts of Electronics & Communication Engineering to design and implement complex systems.

PSO2. Develop hardware, software, or embedded solutions & tools for solving real life problems in electronics and communication domains using acquired knowledge of science, mathematics, and engineering.

PSO3. Engage as an electronics and communication engineering specialist in industry, higher studies, research & development, academics, or as an entrepreneur.

Course Types & Definitions

L	Lecture
T	Tutorial
P	Practical / Sessional
WCH	Weekly Contact Hours
BS	Basic Sciences
HS	Humanities & Social Sciences (including Management)
ES	Engineering Sciences
PC	Professional Core
PE	Professional Elective
OE	Open Elective
MC	Mandatory Course
CC	Compulsory Course
AC	Audit Course
PJ	Project Work
VV	Viva Voce

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Part I

1st Year M.Tech. (ECE)

Curriculum Structure

Semester I									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
PC	18ML1T01	Mathematical Foundations for Communication Engineering	3	0	0	3	0	0
PC	18ML1T02	Wireless and Mobile Communication	3	0	0	3	0	0
PE	18ML2T03	Professional Elective-I	3	0	0	3	0	0
PE	18ML2T04	Professional Elective-II	3	0	0	3	0	0
CC	18MS1T05	Research Methodology & IPR	2	0	0	2	0	0
AC	18MS8T06	Stress Management by Yoga	2	0	0	0	0	0
PRACTICAL									
PC	18ML1L01	Advanced Communication Lab	0	0	4	0	0	2
PC	18ML1L02	IoT & Embedded Systems Design Lab	0	0	4	0	0	2
		SUB-TOTAL	**16**	**0**	**8**	**14**	**0**	**4**
		TOTAL	**24**			**18**		

List of Electives

Code	Elective # and Subjects
	Professional Elective - I
18ML2T01	Advanced Communication Systems
18ML2T02	Statistical Information Processing
18ML2T03	RF & Microwave Circuit Design
	Professional Elective - II
18ML2T04	Microcontrollers & Embedded Systems
18ML2T05	MOSFET Physics & Sub-Micron Device Modeling
18ML2T06	Memory Technologies

Semester II								
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
PC	18ML1T07	Analog & Digital CMOS VLSI Design	3	0	0	3	0	0
PC	18ML1T08	Advanced Digital Signal Processing	3	0	0	3	0	0
PE	18ML2T**	Professional Elective-III	3	0	0	3	0	0
PE	18ML2T**	Professional Elective-IV	3	0	0	3	0	0
AC	18MS8T11	English for Research Paper Writing	2	0	0	0	0	0
PRACTICAL								
PC	18ML1L03	VLSI & Digital System Design Lab	0	0	4	0	0	2
PC	18ML2L04	Advanced Signal Processing Lab	0	0	4	0	0	2
PJ	18ML6L05	Mini Project & Seminar	0	0	4	0	0	2
		SUB-TOTAL	**14**	**0**	**12**	**12**	**0**	**6**
		TOTAL	**26**			**18**		

List of Electives

Code	Elective # and Subjects
	Professional Elective - III
18ML2T07	Satellite Communication
18ML2T08	Digital Image & Video Processing
18ML2T09	Antennas & Radiating Systems
	Professional Elective - IV
18ML2T10	Advanced Embedded Systems
18ML2T11	Internet of Things
18ML2T12	Low Power VLSI Design

Type	Code	Mathematical Foundations for Communication Engineering	L-T-P	Credits	Marks
PC	18ML1T01		3-0-0	3	100

Objectives	The objective of this course is to learn Linear Algebra,Probability theory and other mathematics components which are required to formulate electronics and communication engineering problems.
Pre-Requisites	Knowledge of set theory, matrix algebra, integration, differentiation, and differential equations is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Vector Spaces, subspaces, linear independence, basis, dimension, linear transformation, perpendicular vectors and orthogonal subspaces, inner product and projection, least square approximation, orthogonal basis.	**8 Hours**
Module-2	Probability; Conditional Probability; Bayes' rule; Random Variable & Probability Distribution; some special distributions.	**8 Hours**
Module-3	Joint Distribution, Conditional distribution, Mean, Variance, Covariance, Conditional Expectation, Limit Theorems, Stochastic Process.	**10 Hours**
Module-4	Optimization Techniques: Calculus of several variables, Implicit function theorem, Nature of singular points, Necessary and sufficient conditions for optimization, Constrained Optimization, Lagrange multipliers, Gradient method – steepest descent method.	**8 Hours**
Module-5	Non-linear Differential Equations: Iterative, Variational and Perturbation Methods. Integral Equations: Boundary value problems; Boltzmann transport equation in e.m. field; Hilbert Schmidt theory. Green's Functions : Application to physical problems; Green's function by eigen function method; Solution of initial and boundary value problems.	**10 Hours**
	Total	**44 Hours**

Text Books:

T1. G. Strang, ***Linear Algebra and Applications***, 4th Edition, Cengage Learning, 2005.
T2. S. M. Ross, ***Introduction to Probability Models***, 9th Edition, Elsevier India, 2007.
T3. S. S. Rao, ***Optimization: Theory and Application***, 2nd Edition, Wiley Eastern Ltd., 1984.
T4. T. Sauer, ***Numerical Analysis***, 2nd Edition, Pearson Education, 2012.
T5. M. K. Jain, S. R. K. Iyenger, and P. K. Jain, ***Numerical Methods for Scientific and Engineering Computation***, 4th Edition, New Age International, 2003.

Reference Books:

R1. K. E. Atkinson, ***An Introduction to Numerical Analysis***, John Wiely & Sons, 1989.
R2. S. S. Rao, ***Engineering Optimization: Theory and Practice***, Wiley-Interscience Publication, 1996.
R3. S. R. K. Iyenger and R. K. Jain, ***Numerical Methods***, New Age International, 2009.

Online Resources:

1. http://www.math.iitb.ac.in/~baskar/book.pdf
2. http://www2.math.umd.edu/~dlevy/books/na.pdf
3. http://www.sam.math.ethz.ch/~hiptmair/tmp/NumCSE/NumCSE15.pdf

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand projection in a linear space and apply the concepts to different approximation problems.
CO2	Understand and apply the concepts of probability to probabilistic models.
CO3	Understand and apply the concepts of Stochastic Process to signals.
CO4	Optimize and solve real life problems.
CO5	Evaluate and analyze the boundary value problems of engineering.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO4	Understand and use different software tools for design, analysis and verification in the domain of communication, VLSI and signal processing through design, synthesis, functional, and timing simulation.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	3	2						2	1	1	3
CO2	3	3	3	2						3	1	1	3
CO3	3	3	3	2						2	1	1	3
CO4	3	3	3	3						3	2	1	3
CO5	3	2	3	3						2	3	1	3

Type	Code	Wireless & Mobile Communication	L-T-P	Credits	Marks
PC	18ML1T02		3-0-0	3	100

Objectives	The objective of this course is to impart knowledge on how communication happens in wireless environment, develop knowledge about cellular concepts and it's generations, and motivate students to pursue research in specialized areas to meet industry requirement.
Pre-Requisites	Knowledge of Linear Algebra, Antennas, Digital Communications and Digital Signal Processing are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Cellular Communication Fundamentals: Cellular system design, Frequency reuse, cell splitting, handover concepts, Co channel and adjacent channel interference, interference reduction techniques and methods to improve cell coverage, Frequency management and channel assignment; GSM architecture and interfaces, Mobility Management, High speed Circuit Switched Data (HSCSD), General Packet Radio Service (GPRS), EDGE.	**11 Hours**
Module-2	Spectral efficiency analysis based on calculations for Multiple access technologies: TDMA, FDMA and CDMA, Comparison of these technologies based on their signal separation techniques, advantages, disadvantages and application areas. Wireless network planning (Link budget and power spectrum calculations).	**5 Hours**
Module-3	Mobile Radio Propagation: Ground Reflection (Two-Ray) Model, Signal Fading Statistics, Indoor and Outdoor propagation Model, Multipath Measurements, Doppler Spread.	**9 Hours**
Module-4	Equalization, Diversity: Equalizers in a communications receiver, Algorithms for adaptive equalization, diversity techniques, space, polarization, frequency diversity, Interleaving.	**7 Hours**
Module-5	Code Division Multiple Access: Introduction to CDMA technology, IS 95 system architecture, Air interface, Physical and logical channels of IS 95, Forward link and Reverse link operation, IS 95 Call processing, Soft handoff, Evolution of IS 95 (CDMA One) to CDMA 2000, CDMA 2000 layering structure and channels.	**6 Hours**
Module-6	Higher Generation Cellular Standards: 3G Standards: evolved EDGE, enhancements in 4G standard, Architecture and representative protocols, call flow for LTE, VoLTE, UMTS, introduction to 5G.	**6 Hours**
	Total	**44 Hours**

P.T.O

Text Books:

T1. V. K. Garg, ***Wireless Communication and Networking***, M K Publishers, 2011.
T2. A. Goldsmith, ***Wireless Communications***, Cambridge University Press, 2005.
T3. T. S. Rappaport, ***Wireless Communications: Principles and Practice***, 2nd Edition, PHI, 2002.

Reference Books:

R1. V. K.Garg and J. E. Wilkes, ***Principle and Application of GSM***, 5th Edition, Pearson Education, 2008.
R2. V. K. Garg, ***IS-95 CDMA & CDMA 2000***, 4th Edition, Pearson Education, 2009.
R3. W. C. Y. Lee, ***Mobile Cellular Telecommunications: Analog and Digital Systems***, 2nd Edition, TMH, 1995.
R4. A. Mehrotra, ***A GSM System Engineering***, Artech House Publishers, London, 1997.
R5. D. Tse and P. Viswanath, ***Fundamentals of Wireless Communications***, 1st Edition, Cambridge University Press, 2012.
R6. U. Dalal, ***Wireless Communication***, 1st Edition, Oxford University Press, 2009.

Online Resources:

1. https://nptel.ac.in/courses/117102062/
2. http://freewimaxinfo.com/mobile-communication-technologies.html
3. https://www.gsmfavorites.com/documents/introduction/
4. http://www.mobilecomms-technology.com/projects/cdma_is95/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Design a mobile cellular network and analyze its effects due to interference.
CO2	Understand various multiple-access techniques for mobile communications e.g. FDMA,TDMA, CDMA, and their advantages and disadvantages.
CO3	Understand GSM system architecture, network structure, mobile radio propagation and fading.
CO4	Select the appropriate equalization and diversity scheme for a given wireless system to improve the performance over time-varying Rayleigh fading channels.
CO5	Perform efficient spectral allocation using multiple access techniques such as CDMA, CDMA 2000 and OFDM.
CO6	Gain knowledge of different mobile standards and advanced mobile technologies such as LTE, VoLTE, Wi-Max and coming 5G mobile technology.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.
PO7	Understand the impact of electronics & communications in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	3			1	1			2	3	2	1
CO2	3	3	3			1	1			1	3	1	1
CO3	3	2	3			1	1			2	3	1	2
CO4	3	2	3			1	1			1	3	1	1
CO5	3	3	3			2	2			2	3	2	2
CO6	3	2	3			2	2			3	3	2	2

Type	Code	Advanced Communication Systems	L-T-P	Credits	Marks
PE	18ML2T01		3-0-0	3	100

Objectives	The objective of this course is to provide the students with theoretical background and applied knowledge on concepts of communication signals and systems in single, multi-carrier, fiber optic communication technologies for analyzing and designing optimum communication networks under given constraints.
Pre-Requisites	Knowledge of Fourier analysis, Random Signal Theory, Signals and Systems, Communication Theory or equivalent and basics of fiber optic communication systems are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
	Pre-requisites	**2 Hours**
Module-1	Introduction to Communication Signals & Systems: Representation of Band pass signals and systems, Signal Space Representation, Representation of Digitally Modulated Signals, Spectral Characteristics of Digitally Modulated Signals.	**10 Hours**
Module-2	Optimum Receivers for Additive White Gaussian Noise Channel: Optimum Receiver for Signals Corrupted by AWGN, Performance of the Optimum Receiver for Memory-less Modulation.	**12 Hours**
Module-3	Synchronization in Timing and Frequency: Synchronization, System Architecture, Channel Estimation and Equalization, OFDM based Multiple Access Techniques.	**12 Hours**
Module-4	Optical Fiber Communication System: Introduction to Optical Networks, Optoelectronic Sources, Liquid Crystal Devices and Porous Silicon Optical Devices.	**8 Hours**
	Total	**44 Hours**

Text Books:

T1. J. Proakis, ***Digital Communications***, 4th Edition, McGraw-Hill, 2001.

T2. A. R. S. Bahai, B. R. Saltzberg, and M. Ergen, ***Multi-carrier Digital Communications: Theory and Applications of OFDM***, 2nd Edition, Springer, 2004.

T3. R. Ramaswamy, K.N. Sivarajan, and G. H. Sasaki, ***Optical Networks: A Practical Perspective***, 3rd Edition, Morgan Kaufmann, 2010.

T4. J. M. Senior, ***Optical Fiber Communications: Principles & Practice***, 3rd Edition, Pearson Education, 2010.

T5. G. Keiser, ***Optical Fiber Communications***, 5th Edition, McGraw-Hill Education, 2017.

P.T.O

Reference Books:

R1. B. Sklar and P. K. Ray, ***Digital Communications: Fundamentals and Applications***, 2nd Edition, Pearson Education, 2009.
R2. J. Gowar, ***Optical Communication Systems***, 2nd Edition, Prentice Hall India, 1993.

Online Resources:

1. https://nptel.ac.in/courses/117105144/25
2. www.pearsoned.co.uk/senior-optical
3. https://eceagmr.files.wordpress.com/2014/09/optical-fiber-communications-principles-and-pr.pdf
4. http://www.polaritech.ir/wp-content/uploads/2016/08/Shin-Tson_Wu_Deng-Ke_Yang_Fundamentals_of_LiquidBookFi.pdf
5. https://www.tesisenred.net/bitstream/handle/10803/8458/Cap7OpticalDevices7.pdf?sequence=7&isAllowed=y

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Learn and analyze different types of communication signals and systems.
CO2	Design of various types of digital modulation and demodulation methods with respect to bandwidth, SNR and power spectral efficiencies.
CO3	Learn synchronization, equalization and channel estimation techniques and Analyze the design parameters of multi-carrier communication system based multi access techniques.
CO4	Describe the principles of optical communication networks and optoelectronic sources.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO4	Understand and use different software tools for design, analysis and verification in the domain of communication, VLSI and signal processing through design, synthesis, functional, and timing simulation.
PO5	Design and conduct experiments, analyze and interpret data, utilize programming skills for development of simulation experiments.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.
PO7	Understand the impact of electronics & communications in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	3	3	3		1			2	3	3	2
CO2	3	3	3	2	3		2			2	3	2	1
CO3	3	3	3	3	3	1	3			2	3	3	2
CO4	3	3	3	3	2	1	3			2	3	3	2

Type	Code	Statistical Information Processing	L-T-P	Credits	Marks
PE	18ML2T02		3-0-0	3	100

Objectives	The objective of this course is to expose the students to the basics of probability theory and random processes which are essential for analog and digital communication and enable them to utilize a comprehensive set of descriptive statistical methods to organize, summarize, and display data in a meaningful way.
Pre-Requisites	Basic knowledge of probability and statistics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
	Introduction and Pre-requisites	**2 Hours**
Module-1	Review of random variables: Probability concepts, distribution and density functions, moments, independent, uncorrelated and orthogonal random variables; Vector-space representation of random variables, vector quantization, Chebyshev's inequality theorem, Central Limit theorem, discrete & continuous random variables; Random process: Expectations, Moments, Ergodicity, Discrete-Time random processes, Stationary process, autocorrelation and auto covariance functions, Spectral representation of random signals, Properties of power spectral density, Gaussian process and White noise process.	**9 Hours**
Module-2	Random signal modeling: MA(q), AR(p), ARMA(p, q) models, Hidden Markov Model & its applications, Linear System with random input, Forward and Backward Predictions, Levinson Durbin Algorithm.	**4 Hours**
Module-3	Statistical Decision Theory: Bayes' Criterion, Binary Hypothesis Testing, M-ary Hypothesis Testing, Minimax Criterion, Neyman-Pearson Criterion, Composite Hypothesis Testing; Parameter Estimation Theory: Maximum Likelihood Estimation, Generalized Likelihood Ratio Test, Some Criteria for Good Estimators, Bayes' Estimation, Minimum Mean-Square Error Estimate, Minimum Mean Absolute Value of Error Estimate, Maximum A Posteriori Estimate, Multiple Parameter Estimation, Best Linear Unbiased Estimator, Least-Square Estimation, Recursive Least-Square Estimator.	**10 Hours**
Module-4	Spectral analysis: Estimated autocorrelation function, Periodogram, Averaging the periodogram (Bartlett Method), Welch modification, Parametric method, AR(p) spectral estimation and detection of Harmonic signals.	**4 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	Information Theory and Source Coding: Introduction, Uncertainty, Information and Entropy, Source coding theorem, Huffman, Shanon Fano, Arithmetic, Adaptive coding, RLE, LZW Data compaction, LZ-77, LZ-78; Discrete Memory less channels, Mutual information, channel capacity, Channel coding theorem, Differential entropy and mutual information for continuous ensembles.	**8 Hours**
Module-6	Application of Information Theory: Group, Ring & Field, Vector, GF addition, multiplication rules. Introduction to BCH codes, Primitive elements, Minimal polynomials, Generator polynomials in terms of Minimal polynomials, Some examples of BCH codes & decoder, Reed-Solomon codes & decoder, Implementation of Reed Solomon encoders and decoders.	**7 Hours**
	Total	**44 Hours**

Text Books:

T1. A. Papoulis and S. U. Pillai, ***Probability, Random Variables and Stochastic Processes***, 4th Edition, McGraw-Hill, 2002.
T2. F. J. MacWilliams and N. J. A. Sloane, ***The Theory of Error-Correcting Codes***, 1st Edition, North-Holland, 1983.

Reference Books:

R1. D. G. Manolakis, V. K. Ingle, and S. M. Kogon, ***Statistical and Adaptive Signal Processing***, McGraw Hill, 2000.
R2. M. Barkat, ***Signal Detection and Estimation***, 2nd Edition, Artech House, 2005.
R3. R. G. Gallager, ***Information Theory and Reliable Communication***, 1st Edition, Wiley, 1969.
R4. K. H. Rosen, ***Elementary Number Theory***, 6th Edition, Addison-Wesley, 2010.

Online Resources:

1. https://nptel.ac.in/courses/117105077/9
2. https://nptel.ac.in/courses/117103018/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand the axiomatic formulation of modern Probability Theory and think of random variables and random process as an intrinsic need for the analysis of random phenomena.
CO2	Perform characterization of probability models and function of random variables.
CO3	Understand the concept of statistical decision and parameter estimation.
CO4	Perform spectral analysis of periodic signals.
CO5	Analyze and Implement various codes for compression and transmission of Information.
CO6	Study and analyze the applications of information theory using mathematical modeling.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.

Cont'd...

PO6	Function effectively as an individual or as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.
PO7	Understand the impact of electronics & communications in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	3			2	1			1	3	1	1
CO2	3	3	3			1	2			2	3	1	2
CO3	3	3	3			1	1			2	3	1	2
CO4	3	3	3			2	2			2	3	1	1
CO5	3	3	3			2	2			3	3	2	2
CO6	3	3	3			2	2			3	3	1	2

Type	Code	RF & Microwave Circuit Design	L-T-P	Credits	Marks
PE	18ML2T03		3-0-0	3	100

Objectives	The objective of this course is to impart in-depth knowledge on transmission lines, microwave networks, microwave components, modelling & design of microwave filters & amplifiers, and lay the foundation for exploring the vast area of microwave circuit applications.
Pre-Requisites	Basic knowledge of electromagnetic theory, tools used in microwave engineering and theory of transmission line are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
	Introduction and Pre-requisites	**2 Hours**
Module-1	Transmission Line Theory: Lumped element circuit model for transmission line, field analysis, Smith chart, quarter wave transformer, generator and load mismatch, impedance matching and tuning.	**7 Hours**
Module-2	Microwave Network Analysis: Impedance and equivalent voltage and current analysis, Impedance and admittance matrix, The scattering matrix, transmission matrix, Signal flow graph.	**7 Hours**
Module-3	Microwave Components: Microwave resonators, Microwave filters, power dividers and directional couplers, Ferromagnetic devices and components.	**6 Hours**
Module-4	Nonlinearity And Time Variance Inter-symbol interference, random processes & noise, definition of sensitivity and dynamic range, conversion gain and distortion.	**6 Hours**
Module-5	Microwave Semiconductor Devices And Modeling: PIN diode, Tunnel diodes, Varactor diode, Schottky diode, IMPATT and TRAPATT devices, transferred electron devices, Microwave BJTs, GaAs FETs, low noise and power GaAs FETs, MESFET, MOSFET, HEMT.	**8 Hours**
Module-6	Amplifier Design: Power gain equations, stability, impedance matching, constant gain and noise figure circles, small signal, low noise, high power and broadband amplifier, oscillators, Mixer design.	**8 Hours**
	Total	**44 Hours**

Text Books:

T1. D. M. Pozar, ***Microwave Engineering***, 4th Edition, Wiley, 2011.
T2. S. Y. Liao, ***Microwave Circuit Analysis and Amplifier Design***, Prentice Hall, 1987.
T3. G. D. Vendelin, A.M. Pavio, and U. L. Rohde, ***Microwave Circuit Design using Linear and Non Linear Techniques***, John Wiley, 1990.

Reference Books:

R1. M. M. Radmanesh, ***Advanced RF & Microwave Circuit Design: The Ultimate Guide to Superior Design***, Author House, 2009.
R2. R. Ludwig and P. Bretchko, ***RF Circuit Design: Theory & Applications***, Pearson Education, 2009.
R3. M. M. Radmanesh, ***RF and Microwave Electronics Illustrated***, Pearson Education, 2004.

Online Resources:

1. https://nptel.ac.in/courses/117102012/
2. https://onlinecourses.nptel.ac.in/noc17_ec03/preview

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand transmission line theory, analysis using smith chart, and impedance matching networks.
CO2	Analyze microwave networks using Scattering parameters.
CO3	Study different microwave components such directional couplers, resonators and design various microwave filters.
CO4	Understand random processes and become familiar with sensitivity, dynamic range, conversion gain and distortion.
CO5	Study and model different microwave devices such as Varactor diode, Schottky diode, MESFET, MOSFET and HEMTs.
CO6	Design RF amplifier, mixers and evaluate their performance parameters.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.
PO7	Understand the impact of electronics & communications in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	2			1	1			1	3	1	1
CO2	2	3	2			1	1			1	3	1	1
CO3	3	2	2			1	1			1	2	1	1
CO4	3	3	2			1	2			1	3	2	1
CO5	3	3	2			2	1			1	3	1	1
CO6	3	2	2			2	2			2	2	2	1

Type	Code	Microcontrollers & Embedded Systems	L-T-P	Credits	Marks
PE	18ML2T04		3-0-0	3	100

Objectives	The objective of this course is to enable the students to understand major components that constitutes an embedded system, write & implement programs to solve well defined problems in embedded systems, and become familiar with tools used to develop an embedded environment.
Pre-Requisites	Knowledge of C programming is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with emphasis on developing programming skills.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Typical Embedded System: Core of the Embedded System, Memory, Sensors and Actuators, Communication Interface, Embedded Firmware, Other System Components; Characteristics and Quality Attributes of Embedded Systems; Hardware Software Co-Design and Program Modeling: Fundamental Issues in Hardware Software Co-Design, Computational Models in Embedded Design, Introduction to Unified Modeling Language, Hardware Software Trade-offs.	**8 Hours**
Module-2	Embedded Hardware Design and Development: EDA Tools, how to Use EDA Tool, Schematic Design – Place wire, Bus, port, junction, creating part numbers, Design Rules check, Bill of materials, Net list creation, PCB Layout Design – Building blocks, Component placement, PCB track routing.	**8 Hours**
Module-3	ARM Architecture: ARM Design Philosophy, Registers, Program Status Register, Instruction Pipeline, Interrupts and Vector Table, Architecture Revision, ARM Processor Families; ARM Programming Model – I: Instruction Set, Data Processing Instructions, Addressing Modes, Branch, Load, Store Instructions, PSR Instructions, Conditional Instructions, ARM Programming Model – II: Thumb Instruction Set: Register Usage, Other Branch Instructions, Data Processing Instructions, Single-Register and Multi Register Load Store Instructions, Stack, Software Interrupt Instructions.	**14 Hours**
Module-4	ARM Programming: Simple C Programs using Function Calls, Pointers, Structures, Integer and Floating Point Arithmetic, Assembly Code using Instruction Scheduling, Register Allocation, Conditional Execution and Loops.	**8 Hours**
Module-5	Memory Management: Cache Architecture, Polices, Flushing and Caches, MMU, Page Tables, Translation, Access Permissions, Context Switch.	**6 Hours**
	Total	**44 Hours**

Text Books:

T1. A. N. Sloss, D. Symes, and C. Wright, ***ARM Systems Developer's Guide: Designing & Optimizing System Software***, 1st Edition, Elsevier, 2008.

T2. K. V. Shibu, ***Introduction to Embedded Systems***, 1st Edition, Tata McGraw-Hill, 2009.

Reference Books:

R1. J. W. Valvano, ***Embedded Microcomputer Systems: Real Time Interfacing***, 3rd Edition, Cengage Learning, 2010.
R2. J. K. Peckol, ***Embedded Systems: A Contemporary Design Tool***, 2nd Edition, John Weily, 2008.

Online Resources:

1. https://nptel.ac.in/courses/108102045/
2. https://onlinecourses.nptel.ac.in/noc18_cs05/course
3. https://nptel.ac.in/courses/108102045/31

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Demonstrate Knowledge and Understanding of the Fundamental principles of Embedded Systems, explain the process and apply it.
CO2	Understand and develop the knowledge for microcontroller technology for both hardware & software.
CO3	Design Embedded Systems based on Microcontrollers.
CO4	Demonstrate knowledge and understanding of hardware/software co-design techniques for microcontroller based embedded systems and apply the same in design problems.
CO5	Program microcontrollers in C using integrated development environment and use debugging techniques.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO4	Understand and use different software tools for design, analysis and verification in the domain of communication, VLSI and signal processing through design, synthesis, functional, and timing simulation.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	3	2		2				2	3	2	2
CO2	3	3	3	2		2				2	3	2	1
CO3	3	3	3	2		1				2	3	1	1
CO4	3	3	3	2		2				2	3	2	1
CO5	3	3	3	2		2				3	3	2	2

Type	Code	MOSFET Physics & Sub-Micron Device Modeling	L-T-P	Credits	Marks
PE	18ML2T05		3-0-0	3	100

Objectives	The objective of this course is to do in-depth analysis of MOSFET characteristics and behaviour, study different advanced MOSFETs, and applications of advanced device simulators to verify and compare their characteristics.
Pre-Requisites	Knowledge of of analog & digital electronics, mathematics & physics of MOSFETs, and detailed knowledge regarding SCEs is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
	Introduction and Pre-requisites	**2 Hours**
Module-1	Metal Semiconductor contacts – idealized Metal, Semiconductor junction, current voltage characteristics of schottky barrier, ohmic contacts, surface effects, MOS electronics, capacitance of the MOS system, non-ideal MOS system. Basic MOSFET behavior, Channel length modulation, Body bias effect, Threshold voltage adjustment, Sub threshold conduction.	**12 Hours**
Module-2	Limitation of long channel analysis, short channel effects, mobility degradation, velocity saturation, drain current in short channel MOSFETS, MOSFET scaling and short channel model, CMOS devices, MOSFET scaling goals, gate coupling, velocity overshoot, high field effects in scaled MOSFETs, substrate current, hot carrier effects, effects of substrate current on drain current, gate current in scaled MOSFETS.	**12 Hours**
Module-3	Moore's law, Technology nodes and ITRS, Physical & technological challenges to scaling; Nonconventional MOSFETs: FDSOI, SOI, Multi-gate MOSFETs.	**8 Hours**
Module-4	Numerical Simulation, basic concepts of simulations, grids, device simulation and challenges; Importance of Semiconductor Device Simulators - Key Elements of Physical Device Simulation, Historical Development of the Physical Device Modeling. Introduction to the Silvaco ATLAS Simulation Tool, Examples of Silvaco ATLAS Simulations – MOSFETs and SOI.	**10 Hours**
	Total	**44 Hours**

Text Books:

T1. R. S. Muller and T. I. Kamins, ***Device Electronics for Integrated Circuits***, 3rd Edition, Wiley, 2007.
T2. D. Vasileska, S. M. Goodnick, and G. Klimeck, ***Computational Electronics: Semiclassical and Quantum Device Modeling and Simulation***, 1st Edition, CRC Press, 2010.

Reference Books:

R1. S. Oda and D. Ferry, ***Silicon Nanoelectronics***, 1st Edition, CRC Press, 2005.

Online Resources:

1. https://irds.ieee.org/images/files/pdf/2017/2017IRDS_MM.pdf
2. https://www.semiconductors.org/wp-content/uploads/2018/06/0_2015-ITRS-2.0-Executive-Report-1.pdf
3. https://dynamic.silvaco.com/dynamicweb/jsp/downloads/DownloadManualsAction.do?req=silen-manuals&nm=atlas

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand the behavior and characteristics of MOSFET related to MOS capacitances.
CO2	Understand the concepts of channel length modulation, body bias effect, threshold voltage adjustment, sub-threshold conduction in MOS.
CO3	Acquire in-depth knowledge of different non-conventional advanced MOSFETs and map with ITRS.
CO4	Apply Silvaco ATLAS simulator to study the behavior of different advanced MOSFETs.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO4	Understand and use different software tools for design, analysis and verification in the domain of communication, VLSI and signal processing through design, synthesis, functional, and timing simulation.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	2	1		1				1	3	1	1
CO2	3	3	2	1		1				1	2	1	1
CO3	3	3	3	2		2				2	3	2	2
CO4	3	3	3	3		2				3	3	3	2

Type	Code	Memory Technologies	L-T-P	Credits	Marks
PE	18ML2T06		3-0-0	3	100

Objectives	The objective of this course is to impart knowledge on design, working principles, and shortcomings of various memory technologies available, study advanced memory technologies including packaging, testing, performance analysis & solutions for improvement.
Pre-Requisites	Basic knowledge of Digital Electronics and VLSI Design is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
	Introduction and Pre-requisites	**2 Hours**
Module-1	Random Access Memory Technologies: Static Random Access Memories (SRAMs), SRAM Cell Structures, MOS SRAM Architecture, MOS SRAM Cell and Peripheral Circuit operation, Bipolar SRAM, Advanced SRAM Architectures and Technologies, Application Specific SRAMs.	**7 Hours**
Module-2	DRAMs, CMOS DRAM Cell, BiCMOS DRAM, Error Failures in DRAM, Advanced DRAM Design and Architecture, Application Specific DRAMs. SRAM and DRAM Memory controllers.	**7 Hours**
Module-3	Non-Volatile Memories: Masked ROMs, PROMs, Bipolar & CMOS PROM, EPROMs, Floating Gate EPROM Cell, OTP EPROM, EEPROMs, Non-volatile SRAM, Flash Memories.	**6 Hours**
Module-4	Semiconductor Memory Reliability and Radiation Effects: General Reliability Issues, RAM Failure Modes and Mechanism, Nonvolatile Memory, Reliability Effects, SEP, Radiation Hardening Techniques. Process and Design Issues, Radiation Hardened Memory Characteristics, Radiation Hardness Assurance and Testing.	**7 Hours**
Module-5	Advanced Memory Technologies and High-density Memory Packing Technologies: Ferroelectric Random Access Memories (FRAMs), Gallium Arsenide (GaAs) FRAMs, Analog Memories, Magneto Resistive Random Access Memories (MRAMs), Experimental Memory Devices.	**7 Hours**
Module-6	Memory Hybrids (2D & 3D), Memory Stacks, Memory Testing and Reliability Issues, Memory Cards, High Density Memory Packaging	**6 Hours**
	Total	**44 Hours**

Text Books:

T1. A. K. Sharma, ***Semiconductor Memories: Technology, Testing and Reliability***, Wiley-IEEE Press, 2002.

T2. A. K. Sharma, ***Advanced Semiconductor Memories: Architectures, Designs and Applications***, 1st Edition, Wiley Interscience, 2002.

Reference Books:

R1. K. Itoh, ***VLSI Memory Chip Design***, 1st Edition, Springer, 2001.

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand the basic SRAM cell design and its peripherals.
CO2	Become familiar with different DRAM cell designs and DRAM memory controller.
CO3	Obtain insight into design of various non-volatile memories.
CO4	Analyze the reliability issues and other radiation effects on memory.
CO5	Get updated on other recent trends and advanced memory technologies.
CO6	Become aware of testing and high density memory packaging.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO4	Understand and use different software tools for design, analysis and verification in the domain of communication, VLSI and signal processing through design, synthesis, functional, and timing simulation.
PO5	Design and conduct experiments, analyze and interpret data, utilize programming skills for development of simulation experiments.
PO7	Understand the impact of electronics & communications in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	2	3	2		1			2	3	3	1
CO2	3	3	2	3	2		2			2	3	2	1
CO3	2	3	1	2	2		2			2	2	2	1
CO4	2	3	3	2			1			3	2	1	2
CO5	3	3	2	2	1		1			3	3	1	2
CO6	3	3	3	2	2		2			3	3	2	2

Type	Code	Research Methodology & IPR	L-T-P	Credits	Marks
CC	18MS1T05		2-0-0	2	100

Objectives	The objective of this course is to introduce students to the principles and practices involved in conducting scientific research. The course is designed to cover three broad areas - The Scientific Method and Hypothesis Testing, Review of Literature and writing Technical Reports, and the elements of Intellectual Property Rights (IPR).
Pre-Requisites	Basic knowledge of probability & statistics will be helpful.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to research, its significance and meaning; Types of research - fundamental, pure, theoretical, applied and experimental; Identification of the research problem and formulation of hypothesis; Research design and errors in research, error analysis; The Scientific Method as the established way of doing research; Data collection, measurement and scaling techniques.	**8 Hours**
Module-2	Meaning and need for hypothesis, types of hypothesis, functions and characteristics of a good hypothesis; Statistical Testing of Hypothesis - T-test, Chi-squared test; Sampling methods, types of sampling, probability and non-probability sampling; One-sample and Two-sample tests. Correlation and Regression analysis.	**8 Hours**
Module-3	Literature - types and review; Literature survey using the web, search engines; Journal, report and thesis writing; Types of reports, structure of the research report and presentation of results.	**8 Hours**
Module-4	Code of ethics in research - Intellectual Property Rights; Details of Patents, Copyrights, Trademarks and Trade Secrets.	**6 Hours**
	Total	**30 Hours**

Text Books:

T1. C. R. Kothari & G. Garg, ***Research Methodology: Methods and Techniques***, 2nd Edition, New Age International Publishers, 2004.
T2. D. Chawla & N.Sodhi, ***Research Methodology: Concepts and Cases***, 2nd Edition, Vikas Publishing, 2016.

Reference Books:

R1. E. L. Lehman & J. P. Romano, ***Testing Statistical Hypothesis***, 3rd Edition, Springer, 2008.
R2. R. Panneerselvam, ***Research Methodology***, 2nd Edition, Prentice Hall India, 2013.

P.T.O

Online Resources:

1. http://nptel.ac.in/courses/107108011: NPTEL Course.
2. https://ocw.mit.edu/courses/sloan-school-of-management/15-347-doctoral-seminar-in-research-methods-i-fall-2004/readings/: MIT Open Courseware (MIT-OCW).

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Disseminate the scientific method as a structured way of conducing scientific research.
CO2	Apply statistical principles for conducting hypothesis testing.
CO3	Conduct effective review of literature and write technical reports.
CO4	Acquire knowledge of the various intellectual property rights.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO4	Understand and use different software tools for design, analysis and verification in the domain of communication, VLSI and signal processing through design, synthesis, functional, and timing simulation.
PO5	Design and conduct experiments, analyze and interpret data, utilize programming skills for development of simulation experiments.
PO8	Understand intellectual property rights and overall professional & ethical responsibility.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	1	1	1					1	1	1	2
CO2	2	2	1	1	1					1		1	1
CO3					3				2	1		1	2
CO4								3		1		1	2

Type	Code	Stress Management by Yoga	L-T-P	Credits	Marks
AC	18MS8T06		2-0-0	0	100

Objectives	To impart skills in students for control of mind, body and soul, enhance self-awareness, improve self-awareness, focus, and concentration, bring together physical and mental wellness, manage stress and anxiety, achieve perfect equilibrium and harmony, and promote self-healing.
Pre-Requisites	There are no pre-requisites for this course.
Teaching Scheme	Regular practice classes conducted under supervision of the qualified Yoga teacher with necessary explanation and demonstration for each session.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to Yoga, Pranayama, Mudra, Bandha and Chakra.	**6 Hours**
Module-2	Pawanmuktasana Part 1, various Asanas in standing posture.	**6 Hours**
Module-3	Surya Namaskar set and its benefits.	**6 Hours**
Module-4	Various Asanas in sitting posture.	**6 Hours**
Module-5	Asanas in sleeping posture and various relaxation Asanas.	**6 Hours**
	Total	**30 Hours**

Text Books:

T1. E. F. Bryant, ***The Yoga Sutras of Patanjali***, 1st Edition, North Point Press, 2009.

Reference Books:

R1. Swami Satyananda Saraswati, ***Asana Pranayama Mudra Bandha***, 4th Edition, Yoga Publication Trust, Munger (Bihar), India, 2008.

Online Resources: *There are a number of online resources available for this subject. The student is advised to search on the Internet and locate the required study materials as per advise of the teacher.*

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Promote positive health, prevent stress related health problems and rehabilitation through Yoga.
CO2	Achieve integral approach of Yoga Therapy to common ailments.
CO3	Develop skills to adopt Yoga practices for health and general well-being.
CO4	Develop of overall personality through control of body, mind and soul.
CO5	Enhance scientific attitude and team spirit for creative and constructive endeavors.

P.T.O

Program Outcomes Relevant to the Course:

PO6	Function effectively as an individual or as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1						1			3	2		2	1
CO2										3		1	1
CO3						2			3	3		2	2
CO4									3	3	1	2	2
CO5						2			2	3	1	2	3

Type	Code	Advanced Communication Lab	L-T-P	Credits	Marks
PC	18ML1L01		0-0-4	2	100

Objectives	The objective of this course is to impart hands on exposure of digital modulation and demodulation techniques, designing multi carrier transreceiver, channelling equalizer, analyzing the performance of spread spectrum systems, microwave sources and various antennas, and simulate them using MATLAB/ LabVIEW/ C programming.
Pre-Requisites	Basic knowledge of Digital Communication, image processing, and spread spectrum techniques, random signal theory, wireless communication, EMT, Antenna Theory, and Microwave Engineering are required.
Teaching Scheme	Regular laboratory experiments executed by the students under the supervision of teachers. Demonstration shall be given for each experiment.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
- Communication Lab	
1	Study of PCM, ASK, PSK, FSK, QPSK, Delta, PAM, PPM and PWM Modulation & Demodulation Characteristics and its techniques.
2	Design different pattern of Gaussian function by varying the standard deviation from 1 to 5, using the MATLAB.
3	Design different pattern of Rayleigh function by varying the Rayleigh constant from 1 to 5 using MATLAB.
4	Study of Sampling theorem & reconstruction of signal.
5	Develop algorithm to get the free space path loss propagation by varying the distances between the transmitter & receiver and Compare the result graphically, using the MATLAB.
6	Introduction to LabVIEW with its basic functions and study of modulation toolkit.
7	Study the interfacing of hardware (USRP module) with the PC and configuring the same (LabVIEW).
8	Design and verify the FSK, PSK, QAM, FM, GPS modulator and demodulator (LabVIEW).
9	Design two-dimensional convolution to perform image edge detection.
10	Channel equalizer design (LMS, RLS)
11	OFDM transceiver design
- RF Design Lab	
1	Experimental studies of radiation pattern of Micro strip Yagi-Uda and patch antennas.
2	Impedance measurements of Horn/ Yagi /Dipole/Parabolic antennas.
3	Analysis of E & H plane horns.
4	Determine the directivity and gains of Horn/ Yagi/ dipole/ Parabolic antennas

Cont'd...

Experiment-#	Assignment/Experiment
5	Determination of the modes transit time, electronic timing range and sensitivity of klystron source
6	Conduct an experiment for voice and data multiplexing using optical fiber.
7	Determination of V-I characteristics of GUNN diode, and measurement of guide wave length, frequency, and VSWR.
8	Determination of coupling coefficient and insertion loss of Branch line and backward directional couplers.
9	MATLAB/C implementation to obtain the radiation pattern of different types of antennas.
10	MATLAB /C implementation of n-isotropic sources to obtain Beam area, Beam width between first nulls, and Directivity of End fire antenna array.
11	MATLAB /C implementation of n-isotropic sources to obtain Beam area, Beam width between first nulls, and Directivity of broad side antenna array.

Text Books:

T1. J. Proakis, ***Digital Communications***, 4th Edition, McGraw-Hill, 2001.
T2. T. S. Rappaport, ***Wireless Communications: Principles and Practice***, 2nd Edition, Pearson Education, 2002.
T3. C. A. Balanis, ***Antenna Theory: Analysis and Design***, 4th Edition, John Wiley & Sons, 2016.

Reference Books:

R1. B. P. Lathi and Z. Ding, ***Modern Digital and Analog Communication Systems***, 4th Edition, Oxford University Press, 2010.
R2. B. Sklar and P. K. Ray, ***Digital Communications: Fundamentals and Applications***, 2nd Edition, Pearson Education, 2009.
R3. J. D. Kraus, R. J. Marhefka, and A. S. Khan, ***Antennas for All Applications***, 3rd Edition, Tata McGraw-Hill, 2002.

Online Resources:

1. https://nptel.ac.in/courses/117105144/
2. https://nptel.ac.in/courses/117107035/
3. https://nptel.ac.in/courses/108101092/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Apply various types of digital modulation and demodulation techniques with respect to bandwidth, SNR and power spectral efficiency.
CO2	Design of various probability functions with different values of standard deviations and various antenna using MATLAB/C programming.
CO3	Analyze and design two-dimensional convolution, channel equalizer, OFDM transceiver, sampling & signal reconstruction and various types of spread spectrum techniques.
CO4	Determine radiation pattern, impedance, gains, directivity, etc. of various types of antennas.
CO5	Determine different performance parameters such as transit time, sensitivity, etc. of microwave sources.
CO6	Conduct experiments for voice and data multiplexing using optical fiber, characteristics of microwave components such as directional couplers.

P.T.O

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO4	Understand and use different software tools for design, analysis and verification in the domain of communication, VLSI and signal processing through design, synthesis, functional, and timing simulation.
PO5	Design and conduct experiments, analyze and interpret data, utilize programming skills for development of simulation experiments.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	2	3	3					2	3	3	2
CO2	3	3	2	3	3					2	3	3	2
CO3	3	3	3	3	3					2	3	3	2
CO4	3	2	2	3	3					2	2	3	2
CO5	3	3	2	3	3					2	3	3	2
CO6	3	3	2	2	3					2	3	3	2

Type	Code	IOT & Embedded Systems Design Lab	L-T-P	Credits	Marks
PC	18ML1L02		0-0-4	2	100

Objectives	The objective of this course are to learn fundamental concepts & characteristics of IoT, understand sensors, actuators and gateway devices, get hands-on exposure on designing embedded system using ARM platforms, Real Time Operating Systems and Embedded Linux.
Pre-Requisites	Basic knowledge of digital electronics, microprocessor & microcontrollers, Embedded Systems, and networking are required.
Teaching Scheme	Regular Laboratory experiments executed by the students under supervision of the teacher with focus on problem solving activities and real time applications with the help of software and hardware.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
- Internet of Things (IoT) Lab	
1, 2	Writing assembly level programming to learn basics of LEDs and LCDs.
3	Writing assembly level programming to learn basics of DC Motors.
4	Writing assembly level programming to learn basics of buzzer & switches.
5	Writing assembly level programming to learn basics of Relays.
6, 7	Writing assembly level programming to learn basics of ADC and DAC.
8, 9	Writing assembly level programming to learn basics of I2C and SPI protocols.
10	Write a program to cross communicate between nodes. Write a program to add trigger service to send email, send twitter or send SMS.
11	Writing assembly level programming to on/off of LED through IoT.
12	Writing assembly level programming to get the sensor (temperature) data through IoT.
13	Write a program to send data to cloud using Bluetooth and control device. Write a program to interface Temperature and Humidity sensor and monitor values on cloud using WiFi protocol.
14	Writing interfacing drivers for sensors like reed switch, vibration sensor, water & moisture sensor, PIR motion sensor, dust sensor, touch key, ultrasonic sensor and 10DOF sensor.
15	Project & presentation.
- Embedded Systems Lab	
1	Using ARM microcontroller, write a program to interface GPIO devices like 16X2 LCD, Matrix Keyboard.
2	Using ARM microcontroller, write a program to interface EEPROM using I2C and SPI protocols.

Cont'd...

Experiment-#	Assignment/Experiment
3	Using ARM microcontroller, write a program to interface USB Mass Storage Device and to play the audio from USB mass storage.
4	Using ARM microcontroller, write a program to interface CMOS Camera and displaying the output on TFT.
5	Using RTOS and ARM, write program to create two tasks that wait on a timer whilst the main task loops.
6	Using RTOS and ARM, write program to create two tasks displaying two different messages on LCD.
7	Using RTOS and ARM, write program to send messages to mailbox by one task and reading the message from mailbox by another task.
8	Using RTOS and ARM, write program to send a message to PC through serial port by three different tasks on priority basis.
9	Using RTOS and ARM, write program to create two tasks of the same priority and sets the time slice period to illustrate time slicing.
10	Using RTOS and ARM, write program to demonstrate binary semaphore implementation
11	Using RTOS and ARM, write program to illustrate the use of an event set between an ISR and a task.
12	Using RTOS and ARM, write program to demonstrate the interruptible ISRs.
13	BSP development on ARM9 Target: Kernel, File System, Boot-loader.
14	Writing simple application using embedded Linux on ARM9.
15	Writing "Hello World" device driver. Loading into & removing from Kernel on ARM9 board.

Text Books:

T1. M. Miller, ***The Internet of Things: How Smart TVs, Smart Cars, Smart Homes, and Smart Cities are Changing the World***, 1st Edition, Pearson Education, 2015.
T2. D. Minoli, ***Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications***, 1st Edition, Wiley, 2013.
T3. F. Vahid and T. Givargis, ***Embedded System Design: A Unified Hardware/Software Introduction***, 3rd Edition, Wiley, 2006.

Reference Books:

R1. H. S. Kalsi, ***Electronic Instrumentation***, 3rd Edition, McGraw-Hill, 2010.
R2. J. Yiu, ***The Definitive Guide to the ARM Cortex-M3 and Cortex M4 Processors***, 3rd Edition, Newnes, 2013.
R3. R. Kamal, ***Embedded Systems: Architecture, Programming and Design***, 2nd Edition, McGraw-Hill, 2008.
R4. D. Uckelmann, M. Harrison, and F. Michahelles, ***Architecting the Internet of Things***, Springer, 2011.

Online Resources:

1. https://tools.ietf.org/html/rfc7452
2. http://dret.net/lectures/iot-spring15/protocols
3. https://iot.intersog.com/blog/overview-of-iot-development-standards-and-frameworks/

P.T.O

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain architecture & characteristics of ARM and IoT.
CO2	Explain the of fundamentals of Embedded systems, Real Time Operating Systems (RTOS) and Embedded Linux.
CO3	Application of LEDs, Switches, LCD, sensors and actuators and its behavior through ARM & RTOS.
CO4	Apply the knowledge of gateway devices for designing IoT Applications.
CO5	Exploring Cloud services for IoT Application.
CO6	Build IoT Application for real world use.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO4	Understand and use different software tools for design, analysis and verification in the domain of communication, VLSI and signal processing through design, synthesis, functional, and timing simulation.
PO5	Design and conduct experiments, analyze and interpret data, utilize programming skills for development of simulation experiments.
PO7	Understand the impact of electronics & communications in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	3	2	3		2			1	3	3	1
CO2	2	2	2	3	2		2			1	3	3	1
CO3	3	3	2	3	3		3			3	3	2	3
CO4	3	3	3	2	3		2			2	3	2	3
CO5	2	2	3	2	3		3			3	3	3	2
CO6	2	3	3	2	3		3			3	3	3	3

Type	Code	Analog & Digital CMOS VLSI Design	L-T-P	Credits	Marks
PC	18ML1T07		3-0-0	3	100

Objectives	The objective of this course is to enable the students understand the physics and modeling of MOSFETs, layout of CMOS ICs, power dissipation, static & dynamic logic circuits, analog MOS processes, single stage amplifiers, differential amplifiers, and impact of noise.
Pre-Requisites	Basics on MOSFET, fundamentals on combinational and sequential circuits, and amplifiers are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Digital CMOS Design:		
	Introduction and Pre-requisites	**1 Hours**
Module-1	Review: Basic MOS structure and its static behavior; Quality metrics of a digital design: Cost, Functionality, Robustness, Power, and Delay, Stick diagram and Layout, Wire delay models; Inverter: Static CMOS inverter, Switching threshold and noise margin, Dynamic behavior of CMOS Inverter, Power consumption.	**7 Hours**
Module-2	Physical design flow: Floor planning, Placement, Routing, CTS, Power analysis and IR drop estimation - static and dynamic, ESD protection - human body model, Machine model; Combinational logic: Static CMOS design, Logic effort, Ratioed logic, Pass transistor logic; Dynamic CMOS design: Dynamic logic, Speed and power dissipation in dynamic logic, Cascading dynamic gates, CMOS transmission gate logic.	**8 Hours**
Module-3	Sequential logic: Static latches and registers, Bi-stability principle, MUX based latches, Static SR flip-flops, Master-slave edge-triggered register, Dynamic latches and registers, Concept of pipelining, Pulse registers, Non-bistable sequential circuit; Advanced technologies: Giga-scale dilemma, Short channel effects, High–k, Metal Gate Technology, FinFET, TFET etc.	**8 Hours**
Analog CMOS Design:		
	Introduction and Pre-requisites	**1 Hours**
Module-4	Single Stage Amplifier: CS stage with resistive load, Diode connected load, Current source load, Triode load, CS stage with source degeneration, Source follower, Common gate stage, Cascode stage, Choice of device models; Differential Amplifiers: Basic differential pair, Common mode response, Differential pair with MOS loads, Gilbert cell.	**7 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	Passive and active current mirrors: Basic current mirrors, Cascode mirrors, Active current mirrors; Frequency response of amplifiers: Source follower, Common gate stage, Cascode stage and differential pair, Noise: Statistical characteristics of noise, Types of noise, noise in single stage amplifier.	**7 Hours**
Module-6	Operational amplifiers: One stage OPAMP, Two stage OPAMP, Gain boosting, Common mode feedback, Slew rate, PSRR, Compensation of two stage OPAMP, Other compensation techniques.	**5 Hours**
	Total	**44 Hours**

Text Books:

T1. J. P. Rabaey, A. P. Chandrakasan, and B. Nikolić, ***Digital Integrated Circuits: A Design Perspective***, 2nd Edition, Pearson Education India, 2016.
T2. B. Razavi, ***Design of Analog CMOS Integrated Circuits***, 1st Edition, Tata McGraw-Hill, 2002.
T3. S. -M. Kang and Y. Leblebici, ***CMOS Digital Integrated Circuits: Analysis and Design***, 3rd Edition, McGraw-Hill Education, 2002.

Reference Books:

R1. R. J. Baker, ***CMOS Circuit Design: Layout and Simulation***, 2nd Edition, Wiley, 2009.
R2. P. E. Allen and D. R. Holberg, ***CMOS Analog Circuit Design***, 3rd Edition, Oxford University Press, 2013.
R3. D. A. Pucknell and K. Eshraghian, ***Basic VLSI Design***, 3rd Edition, PHI Learning.

Online Resources:

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5453339/: Emerging Applications for High K Materials in VLSI Technology.

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand the structure and operational analysis of CMOS, investigate static & dynamic characteristics of inverter and estimate delay time and power consumption.
CO2	Understand the physical design flow, design and implement CMOS based combinational and sequential logic circuits.
CO3	Understand different advance technologies of CMOS design.
CO4	Design and investigate different single stage and differential amplifier models.
CO5	Design and implement different passive and active current mirrors, and study their frequency response analysis.
CO6	Analyze different operational amplifiers and compensation techniques for them.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.

Cont'd...

PO4	Understand and use different software tools for design, analysis and verification in the domain of communication, VLSI and signal processing through design, synthesis, functional, and timing simulation.
PO5	Design and conduct experiments, analyze and interpret data, utilize programming skills for development of simulation experiments.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	3	2	2					2	3	2	2
CO2	3	3	3	2	2					2	3	2	2
CO3	3	3	3	1	2					2	3	1	2
CO4	3	3	3	1	2					1	3	1	1
CO5	3	3	3	1	3					1	3	1	1
CO6	3	3	3	1	3					1	3	1	2

Type	Code	Advanced Digital Signal Processing	L-T-P	Credits	Marks
PC	18ML1T08		3-0-0	3	100

Objectives	The objectives of this course is to make the students comprehend mathematical modeling of discrete time random signals, choose appropriate filter structures, estimation, prediction and filtering concepts and techniques, and develop understanding of the DSP based real-time data processing system for various DSP based high speed applications.
Pre-Requisites	Knowledge of Signals & Systems and Digital Signal Processing is required.
Teaching Scheme	Regular classroom lectures with use of signal processing tools as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
	Introduction and pre-requisites.	**2 Hours**
Module-1	Overview of DSP, Characterization in time and frequency, FFT Algorithms, Digital filter design and structures: Basic FIR/IIR filter design & structures, design techniques of linear phase FIR filters, IIR filters by impulse invariance, bilinear transformation, FIR/IIR Cascaded lattice structures, parallel realization of IIR.	**10 Hours**
Module-2	Multi rate DSP, Decimators and Interpolators, Sampling rate conversion, multistage decimator & interpolator, poly phase filters, QMF, digital filter banks, Applications in subband coding.	**5 Hours**
Module-3	Linear prediction & optimum linear filters, stationary random process, forward-backward linear prediction filters, solution of normal equations, AR Lattice and ARMA Lattice-Ladder Filters, Wiener Filters for Filtering and Prediction.	**8 Hours**
Module-4	Adaptive Filters, Applications, Gradient Adaptive Lattice, Minimum mean square criterion, LMS algorithm, Recursive Least Square algorithm.	**6 Hours**
Module-5	Estimation of Spectra from Finite-Duration Observations of Signals. Nonparametric Methods for Power Spectrum Estimation, Parametric Methods for Power Spectrum Estimation, Minimum-Variance Spectral Estimation, Eigen analysis Algorithms for Spectrum Estimation.	**8 Hours**
Module-6	Application of DSP & Multi rate DSP, Application to Radar, introduction to wavelets, application to image processing, design of phase shifters, DSP in speech processing & other applications.	**5 Hours**
	Total	**44 Hours**

Text Books:

T1. J. G. Proakis and D. G. Manolakis, ***Digital Signal Processing: Principles, Algorithm and Applications***, 4th Edition, Prentice Hall, 2007.

Reference Books:

R1. N. J. Fliege, ***Multirate Digital Signal Processing: Multirate Systems -Filter Banks- Wavelets***, 1st Edition, John Wiley and Sons, 1999.
R2. B. W. Suter, ***Multirate and Wavelet Signal Processing***, 1st Edition, Academic Press, 1997.
R3. M. H. Hayes, ***Statistical Digital Signal Processing and Modeling***, John Wiley & Sons, 2002.
R4. S. Haykin, ***Adaptive Filter Theory***, 4th Edition, Prentice Hall, 2001.
R5. D. G. Manolakis, V.K. Ingle, and S. M. Kogon, ***Statistical and Adaptive Signal Processing***, McGraw Hill, 2000.

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand the basics of digital filters along with their characteristics and structures.
CO2	Apply different design techniques for FIR and IIR filters and understand sample rate conversion techniques for multi rate signal processing.
CO3	Get an insight of linear filters and perform critical evaluation of linear predictors using different methods.
CO4	Analyze different adaptive signal processing algorithms and design adaptive DSP systems.
CO5	Estimate the power spectrum of signals through different estimation techniques.
CO6	Apply signal processing to various areas such as speech, image, speech, video, biomedical signal processing, radar etc.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO5	Design and conduct experiments, analyze and interpret data, utilize programming skills for development of simulation experiments.
PO7	Understand the impact of electronics & communications in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	1	1	1		1		1			2	1	1	2
CO2	3	2	2		3		2			3	2	2	2
CO3	2	2	1		2		1			2	2	1	1
CO4	3	3	2		3		3			3	3	3	3
CO5	2	1	1		2		2			3	2	2	2
CO6	3	3	3		3		3			3	3	3	2

Type	Code	Satellite Communication	L-T-P	Credits	Marks
PE	18ML2T07		3-0-0	3	100

Objectives	The objective of this course is to acquire knowledge on modern satellite communication systems for designing different downlinks & uplinks, along with preparation of link budgets to avoid signal outage for effective communications via satellites.
Pre-Requisites	Knowledge of UG level Analog Communication Theory, Digital Communication Theory, Microwave Engineering are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
	Introduction and Pre-requisites	**2 Hours**
Module-1	Architecture of Satellite Communication System: Principles and architecture of satellite Communication, Brief history of Satellite systems, advantages, disadvantages, applications, and frequency bands used for satellite communication and their advantages/drawbacks.	**5 Hours**
Module-2	Orbital Analysis: Orbital equations, Kepler's laws of planetary motion, Apogee and Perigee for an elliptical orbit, evaluation of velocity, orbital period, angular velocity etc., of a satellite, Locating satellites with respect to earth, Look angles determination, concepts of Solar day and Sidereal day.	**6 Hours**
Module-3	Satellite sub-systems: Architecture and Roles of various sub-systems of a satellite system such as Telemetry, tracking, command, and monitoring (TTC & M), Altitude and orbit control system (AOCS), Communication sub-system, power sub-systems, antenna sub-system.	**7 Hours**
Module-4	Typical Phenomena in Satellite Communication: Solar Eclipse on satellite, its effects, remedies for Eclipse, Sun Transit Outage phenomena, its effects and remedies, Doppler frequency shift phenomena and expression for Doppler shift, Range variations and remedies.	**5 Hours**
Module-5	Satellite link budget: Flux density and received signal power equations, Calculation of System noise temperature for satellite receiver, noise power calculation, Drafting of satellite link budget and C/N ratio calculations in clear air and rainy conditions, Case study of Personal Communication system (satellite telephony) using LEO.	**10 Hours**
Module-6	Modulation and Multiple Access Schemes used in satellite communication; Typical case studies of VSAT, DBS-TV satellites and few recent communication satellites launched by NASA/ ISRO. GPS.	**9 Hours**
	Total	**44 Hours**

Text Books:

T1. T. Pratt, C. W. Bostian, and J. E. Allnutt, ***Satellite Communications***, 2nd Edition, Wiley India, 2010.
T2. S. K. Raman, ***Fundamentals of Satellite Communication***, Pearson Education, 2011.

Reference Books:

R1. T. T. Ha, ***Digital Satellite Communications***, Tata McGraw Hill, 2009.
R2. D. Roddy, ***Satellite Communications***, 4th Edition, Tata McGraw-Hill, 2008.
R3. A. K. Maini and V. Agrawal, ***Satellite Communications***, Wiley India, 2011.

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Acquire fundamental knowledge about satellite communication systems.
CO2	Understand and analyze orbital mechanics required for satellite launching systems.
CO3	Analyze and design different satellite subsystems for effective communication.
CO4	Analyze and solve problems related to orbital effects of satellites.
CO5	Analyze and design different practical satellite path links considering different atmospheric propagation effects.
CO6	Analyze and optimize different modulation and multiple accessing techniques in case studies.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO7	Understand the impact of electronics & communications in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	2				2			2	3	1	2
CO2	2	3	2				2			2	3	1	1
CO3	2	2	2				2			3	2	1	2
CO4	2	2	2				1			1	2	1	1
CO5	3	3	3				2			2	3	1	2
CO6	3	3	3				3			2	3	2	2

Type	Code	Digital Image & Video Processing	L-T-P	Credits	Marks
PE	18ML2T08		3-0-0	3	100

Objectives	The objective of this course is to learn various image and video processing techniques which are directly or indirectly employed in different consumer electronics, biomedical, remote sensing, surveillance, machine vision, robotics and many other industrial applications.
Pre-Requisites	Knowledge of sampling, quantization, convolution, correlation, various 1-D filters, digital signal processing, Fourier transform etc., are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
	Introduction and Pre-requisites	**2 Hours**
Module-1	Digital Image and Video Fundamentals: Digital image and video fundamentals and formats, 2-D and 3-D sampling and aliasing, 2-D / 3-D filtering, image decimation/interpolation, video sampling and interpolation, Basic image processing operations, Image Transforms Need for image transforms, DFT, DCT, Walsh, Hadamard transform, Haar transform, Wavelet transform.	**7 Hours**
Module-2	Image and Video Enhancement and Restoration: Histogram, Point processing, filtering, image restoration, algorithms for 2-D motion estimation, change detection, motion-compensated filtering, frame rate conversion, de-interlacing, video resolution enhancement, Image and Video restoration (recovery).	**9 Hours**
Module-3	Image and Video Segmentation: Discontinuity based segmentation- Line detection, edge detection, thresholding, Region based segmentation, Scene Change Detection, Spatiotemporal Change Detection, Motion Segmentation, Simultaneous Motion Estimation and Segmentation Semantic Video Object Segmentation, Morphological image processing.	**8 Hours**
Module-4	Color image Processing: Color fundamentals, Color models and their conversion, Pseudo color image processing, Full color processing	**4 Hours**
Module-5	Image and Video Compression: Lossless image compression including entropy coding, lossy image compression, video compression techniques, and international standards for image and video compression (JPEG, JPEG 2000, MPEG-2/4, H.264, SVC), Video Quality Assessment.	**8 Hours**
Module-6	Object recognition: Image Feature representation and description-boundary representation, boundary descriptors, regional descriptors, feature selection techniques, introduction to classification, supervised and unsupervised learning, Template matching, Bayes classifier.	**7 Hours**
	Total	**45 Hours**

Text Books:

T1. J. W. Woods, ***Multidimensional Signal, Image and Video Processing and Coding***, 2nd Edition, Academic Press, 2011.
T2. R. C. Gonzalez and R. E. Woods, ***Digital Image Processing***, 3rd Edition, Prentice Hall, 2008.
T3. S. Shridhar, ***Digital Image Processing***, 2nd Edition, Oxford University Press, 2016.

Reference Books:

R1. E. A. Bovik, ***Handbook of Image and Video Processing***, 2nd Edition, Academic Press, 2000.
R2. A. M. Tekalp, ***Digital Video Processing***, 2nd Edition, Prentice Hall, 2015.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc18_ee40
2. https://nptel.ac.in/courses/117105079/
3. https://nptel.ac.in/courses/117105135/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand the basic fundamental operations (Spatial-domain and Transform-domain) associated with image and video processing.
CO2	Apply various techniques to enhance and restore degraded 2-D and 3-D signals.
CO3	Learn various techniques to segment a foreground object in a 2-D and 3-D environment.
CO4	Understand the basic algorithms associated with color image processing.
CO5	Understand various methods of image and video Compression.
CO6	Understand various steps and techniques employed for object and pattern recognition.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO7	Understand the impact of electronics & communications in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	3				2			2	3	1	2
CO2	3	3	3				2			2	3	1	2
CO3	3	2	2				2			1	2	1	1
CO4	3	3	2				3			2	2	2	1
CO5	3	2	3				3			1	2	1	1
CO6	3	2	2				3			3	3	2	2

Type	Code	Antennas & Radiating Systems	L-T-P	Credits	Marks
PE	18ML2T09		3-0-0	3	100

Objectives	The basic objective of this course is to acquire knowledge on principle of electromagnetic radiation and study different types of antennas, such as, wire antennas, array antennas, aperture antenna, microstrip patch antenna, reflector antennas, etc.
Pre-Requisites	Knowledge of UG level Network Theory and EMT is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on working principle of different antennas.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
	Introduction and Pre-requisites	**2 Hours**
Module-1	Types of Antennas: Wire antennas, Aperture antennas, Micro strip antennas, Array antennas, Reflector antennas, Lens antennas, Radiation mechanism, Current distribution on thin wire antenna; Fundamental Parameters of Antennas: Radiation Pattern, Radiation Power Density, Radiation Intensity, Directivity, Gain, Antenna efficiency, Beam efficiency, Bandwidth, Polarization, Input impedance, Radiation efficiency, Antenna Vector effective length, Friis Transmission equation, Antenna temperature.	**8 Hours**
Module-2	Linear Wire Antennas: Infinitesimal dipole, Small dipole, Region separation, Finite length dipole, half wave dipole, Ground effects; Loop Antennas: Small Circular loop, Circular Loop of constant current, Circular loop with non uniform current.	**7 Hours**
Module-3	Linear Arrays: Two element array, N Element array: Uniform Amplitude and spacing, Broadside and End fire array, Super directivity, Planar array, Design consideration.	**7 Hours**
Module-4	Aperture Antennas: Huygen's Field Equivalence principle, radiation equations, Rectangular Aperture, Circular Aperture. Horn Antennas: E-Plane, H-plane Sectoral horns, Pyramidal and Conical horns.	**7 Hours**
Module-5	Micro strip Antennas: Basic Characteristics, Feeding mechanisms, Method of analysis, Rectangular Patch, Circular Patch.	**7 Hours**
Module-6	Reflector Antennas: Plane reflector, parabolic reflector, Cassegrain reflectors, Introduction to MIMO.	**6 Hours**
	Total	**44 Hours**

Text Books:

T1. C. A. Balanis, ***Antenna Theory Analysis and Design***, 4th Edition, John Wiley & Sons, 2016.

Reference Books:

R1. J. D. Kraus, R. J. Marhefka, A. S. Khan, ***Antennas for All Applications***, Tata McGraw-Hill, 2002.
R2. R. C. Johnson and H. Jasik, ***Antenna Engineering Hand Book***, McGraw-Hill, 1984.

R3. I. J. Bhal and P. Bhartia, ***Micro-strip Antennas***, Artech House, 1980.

Online Resources:

1. https://nptel.ac.in/courses/117107035/
2. https://nptel.ac.in/courses/108101092/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Recognize different types of antennas and their characteristics.
CO2	Study the principles of operation and design of Linear Wire and Loop Antennas.
CO3	Compute the array factor for an array of identical antennas.
CO4	Understand and design the principles of different types of aperture and horn antennas.
CO5	Acquire knowledge on various microstrip antennas and their characteristics.
CO6	Obtain knowledge on different types of reflector antennas and MIMO technique.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO7	Understand the impact of electronics & communications in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	2				2			3	2	1	2
CO2	3	3	2				2			3	3	1	2
CO3	3	3	2				2			2	3	1	1
CO4	3	3	2				2			3	2	1	2
CO5	3	2	2				3			3	2	1	2
CO6	3	3	3				3			3	3	1	3

Type	Code	Advanced Embedded Systems	L-T-P	Credits	Marks
PE	18ML2T10		3-0-0	3	100

Objectives	The objective of this course is to deepen the knowledge in embedded systems, assimilate new content on advanced level, use core knowledge related to specific design problem and simultaneously integrate, generalise & combine prior knowledge in embedded systems.
Pre-Requisites	Fundamentals of C programming with concepts of functions, Pointers, structures along with basic knowledge of microcontrollers and fundamentals of ARM Architecture are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on advanced concepts of embedded systems.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
	Introduction and Pre-requisites	**2 Hours**
Module-1	Introduction to Embedded Systems: Real time nature of ES, Architectures of ES including multi core architecture, Graphic Processing Units (GPU); Typical Embedded System: Core of the Embedded System, Memory, Sensors and Actuators, Communication Interface, Embedded Firmware, Other System Components, Case Study Raspberry Pi 3.	**8 Hours**
Module-2	Characteristics and Quality Attributes of Embedded Systems: Characteristics of embedded system, Quality Attributes of Embedded System; Hardware Software Co-Design and Program Modeling: Fundamental Issues in Hardware Software Co-Design, Computational Models in Embedded Design, Introduction to Unified Modeling Language (UML), Hardware Software Trade-offs; Embedded Firmware Design and Development: Embedded Firmware Design Approaches, Embedded Firmware Development Languages(C, C++, Python, and VHDL/Verilog), Programming in Embedded C.	**8 Hours**
Module-3	Introduction to SoC: System-on-chip with Zynq, Simple Anatomy of an Embedded SoC, Design Reuse, Raising the Abstraction Level, SoC Design Flow; The Zynq Device: Zynq Application Processing Unit(APU), Note on ARM Model, Programming Logic Fabric, Special Resources(DSP48E1 and Block RAM), GPIO, Communication Interfaces, Zynq Soc Design Overview.	**8 Hours**
Module-4	Device Comparison: Device Selection Criteria, Zynq versus FPGA, Zynq veruss Standard Processor, Zynq versus a Discrete FPGA Processor, Zynq Architecture and Design Flow; Embedded Systems and FPGA: Processors and Buses.	**6 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	USB Basics: Uses and limits, Evolution of an Interface, Bus components, Division of labor; Inside USB Transfer: Transfer basics, Elements of a transfer, USB 2.0 transactions, Ensuring successful transfers; Transfer Types: Control transfers, Bulk transfers, Interrupt transfers, Isochronous transfers; Enumeration: Process and Descriptors.	**6 Hours**
Module-6	Hosts for Embedded Systems: Targeted Host, Targeted Peripheral List, Targeted Host types, Bus current, turning off bus power, Embedded Hosts, Differences from conventional host ports, Functioning as a USB device, OTG devices, A-Device and B-Device, OTG descriptor, Host Negotiation Protocol, Role Swap Protocol.	**6 Hours**
	Total	**44 Hours**

Text Books:

T1. J. L. Hennessy and D. A. Patterson, ***Computer Architecture: A Quantitative Approach***, 5th Edition, Morgan Kaufmann, 2011.
T2. K. V. Shibu, ***Introduction to Embedded Systems***, 2nd Edition, McGraw-Hill Education, 2017.
T3. L. H. Crockett, R. A. Elliot, M. A. Enderwitz, and R. W. Stewart, ***The Zynq Book***, University of Strathclyde Glasgow, 2014.
T4. J. Axelson, ***USB Complete: The Developer's Guide***, 5th Edition, Penram International Publishing (India), 2015.

Reference Books:

R1. T. Givargis and F. Vahid, ***Embedded System Design***, Student Edition, John Wiley & Sons, 2006.
R2. R. Kamal, ***Embedded Systems: Architecture, Programming and Design***, 3rd Edition, Tata McGraw-Hill, 2017.
R3. T. Noergaard, ***Embedded Systems Architecture: A Complete Guide for Engineers and Programmers***, 2nd Edition, Newness, 2013.

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand the concept of multi-core, GPU, firmware architectures along with different interfaces
CO2	Understand the concepts and issues of hardware & software co-design, UML and learn different embedded firmware development languages.
CO3	Understand the design flow of SoC, ARM Model and FPGA.
CO4	Compare and perform critical evaluation of various embedded device platform.
CO5	Learn the fundamentals & architecture of USB and develop embedded systems for real world applications.
CO6	Understand the concepts of host, targeted device, and communication between device to device protocol.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.

Cont'd...

PO4	Understand and use different software tools for design, analysis and verification in the domain of communication, VLSI and signal processing through design, synthesis, functional, and timing simulation.
PO7	Understand the impact of electronics & communications in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	3	3				1			1	2	1	1
CO2	3	3	3	2			2			1	3	2	1
CO3	2	3	3	2			2			2	2	2	2
CO4	3	3	3				2			2	3	1	2
CO5	2	3	3	2			1			1	2	1	1
CO6	3	3	3	3			1			1	3	1	1

Type	Code	Internet of Things	L-T-P	Credits	Marks
PE	18ML2T11		3-0-0	3	100

Objectives	The objective of this course is to understand the interconnection and integration of the physical world with the cyberspace, realize the trends of future networking that will lead to the next industry revolution, and Identify the research opportunities in application of IoT.
Pre-Requisites	Fundamentals of computer networks, basics of communication & internet technology, web technology, Wireless Sensor Network (WSN), Embedded Systems architecture, and Basic idea of Data Analytics are required.
Teaching Scheme	Regular classroom lectures with use of ICT as needed, sessions are planned to be interactive with focus on programming using Python and Raspberry Pi.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
	Introduction and Pre-requisites	**2 Hours**
Module-1	Smart cities and IoT revolution, Fractal cities, From IT to IoT, M2M and peer networking concepts, IPV4 and IPV6.	**6 Hours**
Module-2	Software Defined Networks SDN, From Cloud to fog and MIST networking for IoT communications, Principles of Edge/P2P networking, Protocols to support IoT communications, modular design and abstraction, security and privacy in fog.	**8 Hours**
Module-3	Wireless sensor networks: introduction, IoT networks (PAN, LAN and WAN), Edge resource pooling and caching, client side control and configuration.	**6 Hours**
Module-4	Smart objects as building blocks for IoT, Open source hardware and Embedded systems platforms for IoT, Edge/gateway, IO drivers, C Programming, multithreading concepts.	**8 Hours**
Module-5	Operating systems requirement of IoT environment, study of mbed, RIoT, and Contiki operating systems, Introductory concepts of big data for IoT applications.	**8 Hours**
Module-6	Applications of IoT, Connected cars IoT Transportation, Smart Grid and Healthcare sectors using IoT, Security and legal considerations, IT Act 2000 and scope for IoT legislation.	**6 Hours**
	Total	**44 Hours**

Text Books:

T1. A. Bahaga and V. Madisetti, ***Internet of Things: A Hands-on Approach***, 1st Edition, University Press, 2014.
T2. A. McEwen and H. Cassimally, ***Designing the Internet of Things***, 1st Edition, Wiley, 2013.

Reference Books:

R1. Cuno Pfister, ***Getting Started with Internet of Things***, 1st Edition, O'Reilly Media, 2011.

R2. S. Greengard, ***Internet of Things***, 1st Edition, MIT Press, 2015.

Online Resources:

1. http://www.datamation.com/open-source/35-open-source-tools-for-the-internet-of-things-1.html
2. https://developer.mbed.org/handbook/AnalogIn
3. http://www.libelium.com/50_sensor_applications/
4. http://www.m2mlabs.com/framework: M2MLabs Mainspring
5. http://nodered.org/: Node-RED flow-based programming for the Internet of Things
6. https://github.com/connectIOT/iottoolkit: Implementation of the Smart Object API
7. https://www.arduino.cc/: Arduino (open source IoT project)
8. http://www.zettajs.org/: Zetta (Based on Node.js, Zetta can create IoT servers that link to various devices and sensors)
9. http://www.contiki-os.org/: The Open Source OS for the Internet of Things

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand the concepts and application areas of IoT.
CO2	Determine the market perspective and future challenges of IoT.
CO3	Understand the concepts of wireless sensor networks with client side control and configurations.
CO4	Obtain knowledge on building blocks of Internet of Things and characteristics.
CO5	Realize the revolution of Internet in Mobile Devices, Cloud & Sensor Networks.
CO6	Analyze trade-offs in interconnected wireless embedded sensor networks.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO4	Understand and use different software tools for design, analysis and verification in the domain of communication, VLSI and signal processing through design, synthesis, functional, and timing simulation.
PO7	Understand the impact of electronics & communications in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	3	1			2			2	3	1	1
CO2	2	3	3	2			2			1	3	1	1
CO3	2	3	3	3			2			1	3	2	1
CO4	2	3	2	3			2			2	2	2	2
CO5	2	3	2	3			1			2	2	1	2
CO6	3	2	3	2			2			2	3	2	1

Type	Code	Low Power VLSI Design	L-T-P	Credits	Marks
PE	18ML2T12		3-0-0	3	100

Objectives	The objective of this course is to learn the state-of-art Bi-CMOS low voltage, low-power design techniques for ULSI and Giga-scale integration, process integration, device modeling, and its characterization and discover the latest MOS and bipolar models, breakthroughs in isolation and deep submicron processes along with new approaches of designing logic gates, sequential circuits.
Pre-Requisites	Fundamentals of MOSFET models, CMOS, Bi-CMOS, BJT, Sequential Circuits, and Power dissipation are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving & design based activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
	Introduction and Pre-requisites	**2 Hours**
Module-1	Low power design: Overview, low-voltage & low power design limitations, Silicon-on-Insulator (SOI); MOS/BiCMOS Process Technology and Integration: The Realization of CMOS/Bi-CMOS Processes; Integration and Isolation considerations, Integrated Analog / Digital CMOS Process, Deep submicron processes.	**10 Hours**
Module-2	Low-voltage/Low-power CMOS/BICMOS Processes: Future trends and directions of CMOS/BiCMOS processes SOI CMOS, lateral BJT on SOI; Device behavior and modeling: Advanced MOSFET models, limitations of MOSFET models, Bipolar models, Analytical and Experimental characterization of sub half micron MOS devices, MOSFET in a Hybrid mode environment.	**12 Hours**
Module-3	CMOS and Bi-CMOS logic gates: Conventional CMOS and Bi-CMOS logic gates, Performance evaluation; Low-voltage low-power logic circuits: Comparison of advanced Bi-CMOS Digital circuits, ESD-free Bi-CMOS Digital circuit operation and comparative Evaluation.	**10 Hours**
Module-4	Low power latches and flip flops: Evolution of Latches and Flip flops quality measures for latches and Flip flops, Design perspective; Special techniques: Power Reduction in Clock Networks, CMOS Floating Node, Low Power Bus, Delay Balancing, Low Power Techniques for SRAM.	**10 Hours**
	Total	**44 Hours**

Text Books:

T1. K. -S. Yeo, S. S. Rofail, and W. -L. Goh, ***CMOS/Bi-CMOS ULSI: Low Voltage, Low Power***, 1st Edition, Pearson Education, 2002.
T2. Gary K. Yeap, ***Practical Low Power Digital VLSI Design***, Springer, 2012.

Reference Books:

R1. D. A. Pucknell and K. Eshraghian, ***Basic VLSI Design***, 3rd Edition, PHI Learning.
R2. J. P. Rabaey, A. P. Chandrakasan, and B. Nikolić, ***Digital Integrated Circuits: A Design Perspective***, 2nd Edition, Pearson Education India, 2016.
R3. S. -M. Kang and Y. Leblebici, ***CMOS Digital Integrated Circuits: Analysis and Design***, 3rd Edition, McGraw-Hill Education, 2002.

Online Resources:

1. https://nptel.ac.in/courses/106105034/
2. https://nptel.ac.in/courses/106105161/58

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Learn the principles of design and analysis of Low Power MOS and Bi-CMOS logic circuits.
CO2	Analyze the behavior of different MOSFET models and their limitations.
CO3	Design, analyze, and evaluate performance of digital CMOS/Bi-CMOS circuits and understand the different approaches of Low-power design at circuit level.
CO4	Explore and improve upon the latest techniques used for designing power-efficient logic gates, latches, flip-flops, and memories.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	2							1	3	1	1
CO2	2	3	3							1	3	1	1
CO3	2	3	3							2	2	1	2
CO4	3	3	3							3	3	1	2

Type	Code	English for Research Paper Writing	L-T-P	Credits	Marks
AC	18MS8T11		2-0-0	0	100

Objectives	The objective of this course is to give learners an exposure to different aspects of research related technical writing and to help them write such matter effectively through practice.
Pre-Requisites	Basic knowledge of English grammar and the ability to read and write using the English language.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on technical writing activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Technical Communication: Differentiating between general and technical writing, purpose of writing, plain English, mechanics of writing, elements of style. Essentials of English Grammar: basic word order, tense forms, reported speech, use of passives, conditionals, concord, clauses, common errors.	**9 Hours**
Module-2	Elements of Writing: Process writing, developing an effective paragraph, qualities of a paragraph, structuring a paragraph, types of essays, writing reports.	**5 Hours**
Module-3	Key Reading Skills: sub-skills of reading, local and global comprehension, types of technical texts, critical analysis of technical texts, note-making, the purpose and importance of literature review, evaluating literature.	**5 Hours**
Module-4	Developing Writing Skills: writing abstracts, technical letters, project reports, elements of proposal writing.	**6 Hours**
Module-5	Research and Writing: The research paper as a form of communication, Writing a review of Literature, developing a hypothesis, formulating a thesis statement, plagiarism issues.	**3 Hours**
	Total	**28 Hours**

Text Books:

T1. C. Ellison, ***McGraw-Hill's Concise Guide to Writing Research Papers***, McGraw-Hills, 2010.
T2. A. Wallwork, ***English for Writing Research Papers***, Springer, 2011.
T3. R. A. Day, ***How to Write and Publish a Scientific Paper***, 7th Edition, Greenwood, 2011.

Reference Books:

R1. R. Goldbort, ***Writing for Science***, Yale University Press, 2006.
R2. N. J. Higham, ***Handbook of Writing for the Mathematical Sciences***, 2nd Edition, SIAN, 1998.
R3. C. R. Kothari & G. Garg, ***Research Methodology: Methods and Techniques***, 2nd Edition, New Age International Publishers, 2014.

P.T.O

Online Resources:

1. https://msu.edu/course/be/485/bewritingguideV2.0.pdf: Michigan State University Press, USA, Technical Writing Guide, 2007.
2. http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf: Sentence Structure of Technical Writing, Nicole Kelley, MIT, USA, 2006.
3. http://www.inf.ed.ac.uk/teaching/courses/pi/2017_2018/slides/Technical-Writing-Basics.pdf: Notes from Pocketbook of Technical Writing for Engineers and Scientists by Leo Finkelstein, NY, 2007.
4. https://www.shs-conferences.org/articles/shsconf/pdf/2016/04/shsconf_erpa2016_01090.pdf: A need analysis of technical writing skill of engineering students in India, JCK Evangeline & K. Ganesh, DOI: 10.1051/ shsconf/20162601090, 2016

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand the importance and application of technical communication and apply essentials of English grammar to make research writing effective.
CO2	Apply the elements of technical writing to produce effective research papers.
CO3	Develop critical reading and analysis skills of technical research papers and texts.
CO4	Develop the ability to write technical articles and effectively present the ideas.
CO5	Develop research acumen by understanding the key skills of research.

Program Outcomes Relevant to the Course:

PO6	Function effectively as an individual or as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.
PO7	Understand the impact of electronics & communications in an economic, social and environment context.
PO8	Understand intellectual property rights and overall professional & ethical responsibility.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1						3	1	1	3	3	1	2	3
CO2						3			3	3	1	2	3
CO3						3	1	1	3	3	2	2	3
CO4						2		1	3	3	2	2	3
CO5						2	1	3	3	3	2	2	3

Type	Code	VLSI & Digital System Design Lab	L-T-P	Credits	Marks
PC	18ML1L03		0-0-4	2	100

Objectives	The objective of this course is to impart hands-on skills to visualize & implement complex digital systems by applying the concepts of digital system abstractions and paradigms, and be able to address challenging real-world design problems.
Pre-Requisites	Knowledge of digital electronics is required.
Teaching Scheme	Regular Laboratory classes with use of ICT as and when required, practicals are planned to be interactive with focus on problem solving activities and real time applications with the help of software, FPGA and other peripherals.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
- Analog and Digital CMOS VLSI Design Lab	
1	Study of electrical characteristics of NMOS and PMOS at different bias conditions and determine the device parameters and Channel length modulation factor.
2	Draw the static characteristics and perform transient and AC analysis of CMOS inverter.
3	Three stage and five stage ring oscillator circuit design using Ngspice.
4	Small signal analysis of CMOS inverter using Ngspice.
5	Design of a three OPAMP INA and its CMRR calculation using the TCAD tool Mentor Graphics DA.
6	Layout design and parameter extraction of inverter using MAGIC or Microwind.
7	Design and simulation of Analog circuits using Mentor Tool.
- Embedded Systems Lab	
1	Introduction to EDA Tools for simulation and synthesis using FPGA.
2	Digital Combinational Circuit Modeling and Verification using VHDL.
3	Digital Combinational Circuit Modeling and Verification using Verilog.
4	Digital Sequential Circuit Modeling using VHDL.
5	Synthesis of digital circuits using FPGA.
6	FSMs in HDL: Traffic light controller/Vending machine.
7	simulation and synthesis of Serial adder using HDL.
8	Interface experiments: Stepper motor, DAC.

Text Books:

T1. J. Bhaskar, ***A Verilog HDL Primer***, 3rd Edition, B S Publications, 2008.
T2. P. J. Ashenden, ***Digital Design: An Embedded Systems Approach using Verilog***, Elsevier, 2010.
T3. R. J. Baker, ***CMOS Circuit Design, Layout, and Simulation***, 3rd Edition, Wiley-Blackwell, 2010.

Reference Books:

R1. J. P. Rabaey, A. P. Chandrakasan, and B. Nikolić, ***Digital Integrated Circuits: A Design Perspective***, 2nd Edition, Pearson Education India, 2016.
R2. B. Razavi, ***Design of Analog CMOS Integrated Circuits***, 1st Edition, Tata McGraw-Hill, 2002.
R3. P. E. Allen and D. R. Holberg, ***CMOS Analog Circuit Design***, 3rd Edition, Oxford University Press, 2013.

Online Resources:

1. https://www.csd.uoc.gr/~hy121/2013a/datasheets/ngspice-user-manual.pdf
2. http://www.eletr.ufpr.br/marlio/te159/manualAll.pdf

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Design digital and analog Circuit using CMOS.
CO2	Understand the concept of SPICE and how it is being used for various simulations.
CO3	Use EDA tools like Cadence, Mentor Graphics and other open source software tools like Ngspice.
CO4	Design, test and implement combinational circuits, SSI and MSI sequential digital circuits in HDL to verify their functionality.
CO5	Design and implement arithmetic circuits with HDL.
CO6	Design and implement complex FSMs with HDL on FPGA.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO4	Understand and use different software tools for design, analysis and verification in the domain of communication, VLSI and signal processing through design, synthesis, functional, and timing simulation.
PO5	Design and conduct experiments, analyze and interpret data, utilize programming skills for development of simulation experiments.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	3	3	3					2	3	3	2
CO2	3	3	3	3	3					1	3	3	1
CO3	3	3	3	3	3					2	3	3	2
CO4	3	3	3	2	3					1	3	2	1
CO5	3	3	3	2	3					1	3	2	1
CO6	3	3	3	2	3					2	3	2	2

Type	Code	Advanced Digital Signal Processing Lab	L-T-P	Credits	Marks
PC	18ML1L04		0-0-4	2	100

Objectives	The objective of this course is to design and implement digital signal processing using tools LabVIEW and MATLAB, and simulate various image and video algorithms for solving real life problems.
Pre-Requisites	Knowledge of signals and systems analysis tools along with familiarity with image processing toolbox of MATLAB are required.
Teaching Scheme	Regular lab classes with deliberation basic theoretical concepts, demonstration, problem assignment for mini project, and powerpoint presentation.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
- Digital Signal Processing Lab	
1	Basic Signal Representation.
2	Correlation Auto And Cross.
3	Sampling FFT Of Input Sequence.
4	Butterworth Low pass And High pass Filter Design.
5	Chebychev Type I, II Filters.
6	State Space Matrix from Differential Equation.
7	Normal Equation Using Levinson Durbin.
8	Decimation And Interpolation Using Rationale Factors.
9	Maximally Decimated Analysis DFT Filter.
10	Cascade Digital IIR Filter Realization.
11	Convolution And M Fold Decimation & PSD Estimator.
12	Estimation Of PSD.
13	Inverse Z Transform.
14	Parallel Realization of IIR filter.
- Image and Video Processing Lab	
1	Perform basic operations on images like addition, subtraction etc.
2	Plot the histogram of an image and perform histogram equalization.
3	Implement segmentation algorithms.
4	Perform video enhancement.
5	Perform video segmentation.
6	Perform image compression using lossy technique.
7	Perform image compression using lossless technique.
8	Perform image restoration.

Cont'd...

Experiment-#	Assignment/Experiment
9	Convert a colour model into another.
10	Calculate boundary features of an image.
11	Calculate regional features of an image.

Text Books:

T1. J. G. Proakis and D. G. Manolakis, ***Digital Signal Processing: Principles, Algorithms and Applications***, 4th Edition, Pearson Education, 2007.
T2. R. C. Gonzalez and R. E. Woods, ***Digital Image Processing***, 3rd Edition, Pearson Education, 2008.

Reference Books:

R1. N. J. Fliege, ***Multirate Digital Signal Processing: Multirate Systems, Filter Banks, Wavelets***, 1st Edition, Wiley-Blackwell, 1999.
R2. B. W. Suter, ***Multirate and Wavelet Signal Processing***, 1st Edition, Academic Press, 1997.
R3. M. H. Hayes, ***Statistical Digital Signal Processing and Modeling***, John Wiley & Sons, 2002.
R4. S. Haykin, ***Adaptive Filter Theory***, 5th Edition, Prentice Hall, 2013.
R5. D. G. Manolakis, V. K. Ingle, and S. M. Kogon, ***Statistical and Adaptive Signal Processing***, 4th Edition, Arctech House, 2005.

Online Resources:

1. http://www.nptelvideos.in/2012/12/advanced-digital-signal-processing.html
2. https://nptel.ac.in/courses/117105079/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Carry out simulation of Digital Signal Processing systems.
CO2	Determine the spectrum of a signal using the DFT & FFT.
CO3	Design, analyze, and implement digital filters in MATLAB.
CO4	Determine and plot the frequency response of FIR and IIR filters.
CO5	Estimate and plot the PSD.
CO6	Use MATLAB to simulate and analyze systems for sound and image synthesis.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO4	Understand and use different software tools for design, analysis and verification in the domain of communication, VLSI and signal processing through design, synthesis, functional, and timing simulation.
PO5	Design and conduct experiments, analyze and interpret data, utilize programming skills for development of simulation experiments.
PO10	Continue to learn independently and engage in life-long learning.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	3	3	3					1	3	3	1
CO2	3	3	3	3	3					1	3	3	1
CO3	3	3	3	3	3					2	3	2	2
CO4	3	3	3	2	3					2	3	2	2
CO5	3	3	3	2	3					2	3	2	2
CO6	3	3	3	2	3					3	3	3	2

Part II

2nd Year M.Tech. (ECE)

Curriculum Structure

Semester III									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
PE	18ML2T**	Professional Elective-V	3	0	0	3	0	0
OE	18ML3T**	Open Elective	3	0	0	3	0	0
PRACTICAL									
PJ	18ML7L01	Thesis (Part - I) & Seminar	0	0	20	0	0	10
		SUB-TOTAL	**6**	**0**	**20**	**6**	**0**	**10**
		TOTAL	**26**			**16**		

List of Electives

Code	Elective # and Subjects
	Professional Elective - V
18ML2T13	High Performance Networks
18ML2T14	Pattern Recognition & Machine Learning
18ML2T15	Remote Sensing
	Open Elective
18MA3T01	Business Analytics
18MA3T02	Industrial Safety
18MA3T03	Operations Research
18MA3T04	Cost Management of Engg. Projects
18MA3T05	Composite Materials
18MA3T06	Waste to Energy

Semester IV								
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
PRACTICAL								
PJ	18ML7L02	Thesis (Part-II) & Seminar	0	0	32	0	0	16
		SUB-TOTAL	**0**	**0**	**32**	**0**	**0**	**16**
		TOTAL	**32**			**16**		

Type	Code	High Performance Networks	L-T-P	Credits	Marks
PE	18ML2T13		3-0-0	3	100

Objectives	The objective of this course is to introduce the students regarding the design, modeling and analysis of computer networks and network protocols to solve various network engineering problems.
Pre-Requisites	Basic analytical & logical understanding regarding computer networks, network protocols, probability and statistics is required for this course. Prior experience with any modern networking tool will be beneficial.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Types of Networks, Network design issues, Data in support of network design. Network design tools, protocols and architecture. Streaming stored Audio and Video, Best effort service, protocols for real time interactive applications, Beyond best effort, scheduling and policing mechanism, integrated services, and RSVP-differentiated services.	**7 Hours**
Module-2	VOIP system architecture, protocol hierarchy, Structure of a voice endpoint, Protocols for the transport of voice media over IP networks. Providing IP quality of service for voice, signaling protocols for VOIP, PSTN gateways, VOIP applications.	**8 Hours**
Module-3	VPN-Remote-Access VPN, site-to-site VPN, Tunneling to PPP, Security in VPN. MPLS operation, Routing, Tunneling and use of FEC, Traffic Engineering, MPLS based VPN, overlay networks - P2P connections.	**8 Hours**
Module-4	Traffic Modeling: Little's theorem, Need for modeling, Poisson modeling, Non-poisson models, Network performance evaluation.	**6 Hours**
Module-5	Network Security and Management: Principles of cryptography, Authentication, integrity, key distribution and certification, Access control and fire walls, attacks and counter measures, security in many layers.	**7 Hours**
Module-6	Infrastructure for network management, The internet standard management framework – SMI, MIB, SNMP, Security and administration, ASN.1.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. A. Kershenbaum, ***Telecommunications Network Design Algorithm***, Tata McGraw-Hill, 1993.
T2. L. Peterson and B. Davie, ***Computer Networks: A System Approach***, 3rd Edition, Morgan Kaufmann, 2003.

Reference Books:

R1. J. Warland and P. Varaiya, ***High-Performance Communication Networks***, Morgan Kaufmann, 1996.
R2. B. Douskalis, ***IP Telephony: The Integration of Robust VoIP Services***, Pearson Education, 2000.

Online Resources:

1. https://www.amazon.com/Telecommunications-Network-Design-AlgorithmsKershenbaum/dp/0070342288
2. http://cs.mvnu.edu/twiki/pub/Main/JimSkon/Computer_Networks_A_Systems_Approach.pdf
3. https://books.google.co.in/books?isbn=1558605746

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Apply knowledge of mathematics, probability and statistics to model and analyze some networking protocols.
CO2	Design, implement and analyze computer networks.
CO3	Identify, formulate and solve network engineering problems.
CO4	Show knowledge of contemporary issues in high performance computer networks. Use techniques, skills and modern networking tools necessary for engineering practice.
CO5	Learn different network management principles to resolve various network security issues.
CO6	Learn infrastructure for network management and the internet standard management framework.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO4	Understand and use different software tools for design, analysis and verification in the domain of communication, VLSI and signal processing through design, synthesis, functional, and timing simulation.
PO5	Design and conduct experiments, analyze and interpret data, utilize programming skills for development of simulation experiments.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	2	2						2	2	1	2
CO2	3	2	3	2						2	3	2	2
CO3	3	3	1	2						2	3	2	2
CO4	1	3	1	1						2	2	1	1
CO5	3	2	1	1						1	2	1	1
CO6	2	1	1		1					1	2	1	1

Type	Code	Pattern Recognition & Machine Learning	L-T-P	Credits	Marks
PE	18ML2T14		3-0-0	3	100

Objectives	The objective of this course is to introduce pattern recognition, linear models, neural networks, linear discriminant functions, learning methodologies to resolve various real-time and off-line engineering problems and their applications.
Pre-Requisites	Basic idea about least mean square algorithm, genetic algorithm, probability and statistics are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to Pattern Recognition: Problems, applications, design cycle, learning and adaptation, examples, probability distributions, parametric Learning – maximum likelihood and Bayesian decision theory – Bayes rule, discriminant functions, loss functions and Bayesian error analysis.	**8 Hours**
Module-2	Linear models: Linear models for regression, linear regression, logistic regression Linear models for classification.	**6 Hours**
Module-3	Neural Network: perceptron, multi-layer perceptron, back-propagation algorithm, error surfaces, practical techniques for improving back-propagation, deep learning.	**8 Hours**
Module-4	Linear discriminant functions - decision surfaces, two-category, multi-category, minimum squared error procedures, the Ho-Kashyap procedures, linear programming algorithms, Support Vector Machine.	**7 Hours**
Module-5	Algorithm independent machine learning -– lack of inherent superiority of any classifier, bias and variance, re-sampling for classifier design, combining classifiers.	**7 Hours**
Module-6	Unsupervised learning and clustering – k-means clustering, fuzzy k-means clustering, hierarchical clustering.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. R. O. Duda, P. E. Hart, and D. G. Stork, ***Pattern Classification***, 2nd Edition, John Wiley & Sons, 2001.
T2. C. Bishop, ***Pattern Recognition and Machine Learning***, Springer, 2006.

Reference Books:

R1. T. Hastie, R. Tibshirani, and J. H. Friedman, ***The Elements of Statistical Learning***, 2nd Edition, Springer, 2009.

P.T.O

Online Resources:

1. https://pdfentity.co/downloads/pattern_classification_and_scene_analysis_duda_hart.pdf
2. http://users.isr.ist.utl.pt/~wurmd/Livros/school/Bishop%20-%20Pattern%20Recognition%20And%20Machine%20Learning%20-%20Springer%20%202006.pdf
3. https://web.stanford.edu/~hastie/Papers/ESLII.pdf

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Study the parametric and linear models for classification.
CO2	Design neural network and SVM for classification.
CO3	Develop machine independent and unsupervised learning techniques.
CO4	Develop innovative techniques to solve various engineering problems using machine learning and pattern recognition.
CO5	Learn about various applications of machine learning and pattern recognition.
CO6	Understand unsupervised learning and various clustering techniques.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO4	Understand and use different software tools for design, analysis and verification in the domain of communication, VLSI and signal processing through design, synthesis, functional, and timing simulation.
PO5	Design and conduct experiments, analyze and interpret data, utilize programming skills for development of simulation experiments.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	1	2		1						1	1	1	1
CO2	2	2	1	2	1					2	2	2	2
CO3	2	2	1	1	1					2	2	1	2
CO4	3	2	1	2	1					2	2	2	2
CO5	1	2	1	2						2	3	2	1
CO6	3	1	2	3	2					2	2	2	1

Type	Code	Remote Sensing	L-T-P	Credits	Marks
PE	18ML2T15		3-0-0	3	100

Objectives	The objective of this course is to introduce the students regarding the basic concepts, principles and applications of different types of remote sensing technologies related to data collection, radiation, resolution, sampling, and processing & analysis of the sensed data for making interpretations.
Pre-Requisites	Basic idea and undergraduate level knowledge about RADAR, sensors, microwave communication and image processing is necessary.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities and real-life applications.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Physics of Remote Sensing: Electro-magnetic spectrum, physics of remote sensing effects of atmosphere, scattering, different types of absorptions, atmospheric window, energy interaction with surface features, spectral reflectance of vegetation, soil and water atmospheric influence on spectral response patterns, multi concept in remote sensing.	**7 Hours**
Module-2	Data Acquisition: Types of platforms, different types of aircrafts, manned and unmanned spacecrafts, sun synchronous and geo synchronous satellites, types and characteristics of different platforms LANDSAT, SPOT, IRS, INSAT, IKONOS, QUICKBIRD etc.	**6 Hours**
Module-3	Photographic products, B/W, color, color IR film and their characteristics, resolving power of lens and film, opto mechanical electro optical sensors, across track and along track scanners, multispectral scanners and thermal scanners, geometric characteristics of scanner imagery, calibration of thermal scanners.	**7 Hours**
Module-4	Scattering System: Microwave scatterometry, types of RADAR, SLAR, resolution -– range and azimuth, real aperture and synthetic aperture RADAR. Characteristics of microwave images, topographic effect, different types of Remote Sensing platforms, airborne and space borne sensors, ERS, JERS, RADARSAT, RISAT, Scatterometer, Altimeter-LiDAR remote sensing, principles, applications.	**7 Hours**
Module-5	Thermal And Hyper Spectral Remote Sensing: Sensors characteristics, principle of spectroscopy, imaging spectroscopy, field conditions, compound spectral curve, spectral library, radiative models, processing procedures, derivative spectrometry, thermal remote sensing, thermal sensors, principles, thermal data processing, applications.	**7 Hours**

Cont'd...

Module-#	Topics	Hours
Module-6	Data Analysis: Resolution: Spatial, spectral, radiometric and temporal resolution, signal to noise ratio, data products and their characteristics, visual and digital interpretation, basic principles of data processing, Radiometric correction –– Image enhancement, image classification, principles of LiDAR, aerial laser terrain mapping.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. T. M. Lillesand and R. W. Kiefer, ***Remote Sensing and Image interpretation***, 6th Edition, John Wiley & Sons, 2000.
T2. J. R. Jensen, ***Introductory Digital Image Processing: A Remote Sensing Perspective***, 2nd Edition, Taylor & Francis, 1995.

Reference Books:

R1. J. A. Richards, ***Remote Sensing Digital Image Analysis***, 5th Edition, Springer Verlag, 2013.
R2. P. J. Curran, ***Principles of Remote Sensing***, John Wiley & Sons, 1993.

Online Resources:

1. https://www.researchgate.net/publication/282512941_Remote_Sensing_and_Image_Interpretation_7th_Edition
2. https://pdfs.semanticscholar.org/1875/34828113d3c947dcb23cda956c691c9660d3.pdf
3. http://www.gbv.de/dms/goettingen/186021380.pdf

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand basic concepts, principles and applications of remote sensing, particularly the geometric and radiometric principles.
CO2	Provide examples of applications of principles to a variety of topics in remote sensing, particularly related to data collection, radiation, resolution, and sampling.
CO3	Learn different types of scanner, electro-optical sensors along with their calibration.
CO4	Understand the principle of operation of different types of RADAR and learn different remote sensing platforms.
CO5	Learn the principles of thermal and hyper spectral remote sensing, spectroscopy and spectrometry.
CO6	Understand the principles of data analysis, data processing, visual interpretation and radiometric corrections.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO4	Understand and use different software tools for design, analysis and verification in the domain of communication, VLSI and signal processing through design, synthesis, functional, and timing simulation.

Cont'd...

PO5	Design and conduct experiments, analyze and interpret data, utilize programming skills for development of simulation experiments.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	1	1	1					2	2	1	1
CO2	3	2	2	1	1					1	2	1	1
CO3		2		1						1	1	1	1
CO4	2	2		2						1	2	1	1
CO5	2	2	1	2						2	2	2	1
CO6	1	2		3						2	1	2	1

Type	Code	Business Analytics	L-T-P	Credits	Marks
OE	18MA3T01		3-0-0	3	100

Objectives	The objective of this course is to gain understanding of the role of business analytics within an organization, formulation of decision making problems and solving those problems through statistical and data mining techniques.
Pre-Requisites	Basic knowledge of Statistics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities and real-life applications.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction to Business Analytics**: Evolution and scope of business analytics, Relationship of business analytics and organization, Competitive advantages of business analytics, Overview of problem formulation, data collection, model selection and problem solving	**5 Hours**
Module-2	**Data Exploration**: Visualizing data, Measures of location, dispersion and association, Summarization of grouped and categorical data	**5 Hours**
Module-3	**Descriptive Analytics**: Common probability distributions, Sampling and parameter estimation, Confidence intervals, Hypothesis testing, Analysis of variance.	**12 Hours**
Module-4	**Predictive Analytics**: Regression analysis, Forecasting models for stationary time series and time series with linear trend, Data classification using k-nearest neighbor, logistic regression and association rule mining.	**12 Hours**
Module-5	**Prescriptive Analytics**: Formulating decision problems, Creating decision strategies, Using decision trees and linear optimization, Developing information policy, Ensuring data quality, Measuring contribution of business analytics.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. M. J. Schniederjans, D. G. Schniederjans, and C. M. Starkey, ***Business Analytics: Principles, Concepts, and Applications***, 1st Edition, Pearson FT Press, 2014.
T2. J. Evans, ***Business Analytics***, 2nd Edition, Pearson Education, 2016.

Reference Books:

R1. J. Cadle, M. Eva, K. Hindle, D. Paul, C. Rollason, P. Turner, and D. Yeates, ***Business Analysis***, 3rd Edition, BCS, The Chartered Institute for IT, 2014.
R2. W. Winston, ***Business Analytics: Data Analysis & Decision Making***, 5th Edition, South-Western College Publishing, 2014.
R3. R. Bartlett, ***A Practitioner's Guide To Business Analytics: Using Data Analysis Tools To Improve Your Organization's Decision Making And Strategy***, 1st Edition, McGraw-Hill Professional, 2013.

Online Resources:

1. https://nptel.ac.in/courses/110105089/
2. https://nptel.ac.in/courses/110107092/
3. http://mgencer.com/files/BA/BA464-index.html: Business Analytics Lecture Notes

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Demonstrate broader knowledge of the role and importance of data analytics.
CO2	Explore and visualize data.
CO3	Fit data to specific distributions, estimate parameters and test their hypotheses.
CO4	Demonstrate the ability to use technical skills in predictive analytics.
CO5	Translate data into clear, actionable insights using prescriptive modeling.

Program Outcomes Relevant to the Course:

PO4	Understand and use different software tools for design, analysis and verification in the domain of communication, VLSI and signal processing through design, synthesis, functional, and timing simulation.
PO5	Design and conduct experiments, analyze and interpret data, utilize programming skills for development of simulation experiments.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.
PO7	Understand the impact of electronics & communications in an economic, social and environment context.
PO8	Understand intellectual property rights and overall professional & ethical responsibility.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1				1	2					1	1	2	
CO2					2	1	2			2	1	2	1
CO3					2	2		1		1	2	1	1
CO4				2	2	2	1			1	1	1	1
CO5				2	2	2	1			1	1	1	1

Type	Code	Industrial Safety	L-T-P	Credits	Marks
OE	18MA3T02		3-0-0	3	100

Objectives	The objective of this course is to provide knowledge of safety, risk management, laws, hazard analysis & assessment, and topics pertinent to industrial operations and workplace safety.
Pre-Requisites	Basic ideas of industrial safety and regulations would be helpful.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on case studies & real-world examples.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction to Industrial Safety**: Definition, safety policy, organizational safety, accident, causes, types, results and control; Safety concerning wash rooms, drinking water, electrical safety; Cleanliness, pressure vessels, safety color codes, fire prevention and firefighting, equipment and methods.	**8 Hours**
Module-2	**Fundamentals of Maintenance Engineering**: Definition and aim of maintenance engineering; Primary and secondary functions and responsibility of maintenance department; Types of maintenance and applications of tools used for maintenance, Maintenance costs, Service life of equipment, Periodic inspection-concept, cleaning and repairing schemes, repair complexities and its use, definition, need, steps and advantages of preventive maintenance, Steps/procedures for periodic and preventive maintenance.	**8 Hours**
Module-3	**Wear & Corrosion and their Prevention**: Wear – types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general layouts; Corrosion – definition, principle and factors affecting corrosion, Types of corrosion, corrosion prevention methods.	**8 Hours**
Module-4	**Hazard, Risk Issues and Hazard Assessment**: Introduction to hazards, hazard monitoring-risk issue, Hazard assessment, procedure, methodology; Safety audit, checklist analysis, what-if analysis, safety review, preliminary hazard analysis (PHA), Hazard analysis (HAZAN), hazard operability studies (HAZOP), Types of Hazards, causes and preventive steps/procedures.	**9 Hours**
Module-5	**Regulations for Health, Safety and Environment**: Factories act and rules -– Workmen's Compensation Act; Indian Explosives Act – Gas cylinder rules -– SMPV (Static and Mobile Pressure Vessels) Act – Indian Petroleum Act and Rules; Environmental Protection Act (EPA); Manufacture, Storage and Import of Hazardous Chemical rules 1989, Indian Electricity Act and Rules, Overview of OSHA (US), OHSAS 18000 and ISO 14000 (India); Representative case studies.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. R. K. Jain and S. S. Rao, ***Industrial Safety, Health and Environment Management Systems***, 4th Edition, Khanna Publishers, 2017.

Reference Books:

R1. L. M. Deshmukh, ***Industrial Safety Management***, 1st Edition, Tata McGraw-Hill, 2005.
R2. A. Gupta, ***Industrial Safety and Environment***, 1st Edition, Laxmi Publications, 2006.
R3. R. C. Mishra and K. Pathak, ***Maintenance Engineering and Management***, 2nd Edition, Prentice-Hall India, 2012.
R4. H. P. Garg, ***Industrial Maintenance***, 4th Edition, S. Chand & Co., 2012.

Online Resources:

1. https://nptel.ac.in/courses/110105094/
2. https://nptel.ac.in/courses/112107143/40
3. https://nptel.ac.in/courses/103106071/
4. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-863j-system-safety-spring-2016/lecture-notes/MIT16_863JS16_LecNotes7.pdf

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Apply concepts of safety policies used to prevent accidents and recognize hazards.
CO2	Understand fundamentals of maintenance engineering and applications.
CO3	Apply concepts regarding wear, corrosion and their prevention in industrial settings.
CO4	Understand hazards, risk issues and hazard assessment methods.
CO5	Become familiar with regulations for health, safety and environment.

Program Outcomes Relevant to the Course:

PO6	Function effectively as an individual or as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.
PO7	Understand the impact of electronics & communications in an economic, social and environment context.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1						1	1		1	1		1	1
CO2						2	1		2	2		1	1
CO3						1	1		1	1	1	2	2
CO4						2	1		2	2	1	2	2
CO5						2	1		2	2	1	2	2

Type	Code	Operations Research	L-T-P	Credits	Marks
OE	18MA3T03		3-0-0	3	100

Objectives	The objective of this course is to know the methods to optimize the processes, algorithms, solve large-scale industrial optimization problems, and implement the solution processes.
Pre-Requisites	Basic concepts of multivariable functions, maxima & minima, matrices, probability theory and capability of understanding algorithmic computation are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Concept of OR, Formulation of Linear Programming models, Graphical Solution, Simplex technique, Solution of artificial variables of LPP.	**8 Hours**
Module-2	Revised Simplex method, Duality theory, Dual Simplex method, Sensitivity Analysis, Integer Programming.	**8 Hours**
Module-3	Non-linear programming problem: Lagrange's method , Kuhn Tucker condition, Quadratic Programming problem, Dynamic Programming: Forward and Backward Recursion, Knapsack/cargo loading model, solution by Bellman's Optimality principle.	**10 Hours**
Module-4	Game theory: Two Person Zero sum game, Games with and without Saddle point, graphical method and LPP model, Scheduling a project with CPM, Scheduling a project with PERT, Time-cost trade offs.	**8 Hours**
Module-5	Queuing model, Birth and death process, Single Server Models, Multi Server Models, non-exponential models; Deterministic Inventory model, continuous and periodic review models.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. H. A. Taha, ***Operations Research: An Introduction***, 8th Edition, Pearson Education, 2007.
T2. F. S. Hiller and G. J. Lieberman, ***Introduction to Operations Research***, 7th Edition, McGraw-Hill Education, 2001.

Reference Books:

R1. K. Swarup, P. K. Gupta, and M. Mohan, ***Operations Research***, 9th Edition, S. Chand & Sons, 2008.
R2. J. K. Sharma, ***Operations Research Theory and Application***, 5th Edition, MacMillan India, 2013.
R3. W. L. Winston, ***Operations Research Application and Algorithm***, 4th Edition, Cengage Learning, 2004.

P.T.O

Online Resources:

1. https://nptel.ac.in/courses/111105039/
2. https://nptel.ac.in/courses/108104112/
3. https://nptel.ac.in/courses/111105100/
4. https://nptel.ac.in/courses/105108127/
5. https://nptel.ac.in/courses/106108056/
6. https://nptel.ac.in/courses/108103108/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand and apply simplex method to solve a linear programming problem.
CO2	Apply post optimal analysis methods of a LPP.
CO3	Apply dynamic programming methods to solve problems.
CO4	Understand and apply the concepts of game theory and network analysis in decision making.
CO5	Understand and use queuing and inventory models.

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO2	Identify, formulate and solve engineering problems in the broad areas like Systems Design using communication, VLSI, Embedded Platforms and tools.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO4	Understand and use different software tools for design, analysis and verification in the domain of communication, VLSI and signal processing through design, synthesis, functional, and timing simulation.
PO5	Design and conduct experiments, analyze and interpret data, utilize programming skills for development of simulation experiments.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	1	2	2	3						2	1	1
CO2	3	1	3	3	3						2	1	1
CO3	2	2	3	2	3						3	2	1
CO4	3	2	3	2	3						3	2	1
CO5	3	2	3	2	3						3	2	1

Type	Code	Cost Management of Engineering Projects	L-T-P	Credits	Marks
OE	18MA3T04		3-0-0	3	100

Objectives	The objective of this course is to provide knowledge of cost estimation, cost control, pricing, break-even analysis & budget preparation for engineering projects, and introduce use of quantitative methods, model formulation & applications for solving business decision problems.
Pre-Requisites	Basic knowledge in Mathematics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction and Overview of the Strategic Cost Management Process Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Objectives of a Costing System; Inventory valuation and control; Creation of a Database for operational control; Provision of data for Decision-Making.	**7 Hours**
Module-2	Project: meaning, different types, why to manage, cost overruns centres; Various Stages of Project Execution: conception to commissioning; Project execution as conglomeration of technical and nontechnical activities; Detailed Engineering activities; Pre project execution main clearances and documents Project team: Role of each member; Importance Project site: Data required with significance; Project contracts, Types and contents; Project execution, Project cost control, Bar charts and Network diagrams, Project commissioning: mechanical and process.	**8 Hours**
Module-3	Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis; Various decision-making problems; Standard Costing and Variance Analysis.	**9 Hours**
Module-4	Pricing strategies: Pareto Analysis, Target costing, Life Cycle costing, Costing of service sector, Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints; Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis; Budgetary Control, Flexible Budgets, Performance budgets, Zero-based budgets; Measurement of Divisional profitability pricing decisions including transfer pricing.	**10 Hours**
Module-5	Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Lal, ***Advanced Management Accounting: Text, Problems and Cases***, 4th Edition, S. Chand Publication, 2016.
T2. A. K. Bhattacharya, ***Principles & Practices of Cost Accounting***, 3rd Edition, PHI, 2010.
T3. N. D. Vohra, ***Quantitative Techniques in Management***, 3rd Edition, Tata McGraw-Hill, 2007.

Reference Books:

R1. C. T. Horngren, S. M. Datar, and M. V. Rajan, ***Cost Accounting: A Managerial Emphasis***, 14th Edition, Prentice Hall of India, 2011.
R2. M. C. Shukla, T. S. Grewal, and M. P. Gupta, ***Cost Accounting: Texts and Problems***, 1st Edition, S Chand & Company, 2007.
R3. R. Panneerselvam, ***Production and Operations Management***, 3rd Edition, PHI, 2012.
R4. M. Y. Khan and P. K. Jain, ***Management Accounting***, 7th Edition, McGraw-Hill Education, 2017.

Online Resources:

1. https://www.scribd.com/doc/78419405/Strategic-Cost-Analysis
2. https://www.accountingtools.com/articles/what-is-inventory-valuation.html
3. http://www.umsl.edu/~sauterv/analysis/488_f02_papers/ProjMgmt.html
4. http://cost-edu.blogspot.com/p/basic-cost-concepts.html
5. https://www.imanet.org.cn/uploads/resource/2015-11/1447060485-6834.pdf
6. http://www.interventions.org/pertcpm/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand the concept of cost accounting and its application in evaluating engineering project.
CO2	Execute the project as per the plan and control the project execution cost.
CO3	Asses how cost-volume-profit is related and uses CVP analysis as a planning and decision making aid.
CO4	Price the products based on different pricing technique.
CO5	Understand the mathematical tools that are needed to solve optimization problems.

Program Outcomes Relevant to the Course:

PO6	Function effectively as an individual or as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.
PO8	Understand intellectual property rights and overall professional & ethical responsibility.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1						1			1	1	1	1	1
CO2								1		1			1
CO3						1		1		1		1	1
CO4						1			1	1		2	1
CO5								1	1	1		1	1

Type	Code	Composite Materials	L-T-P	Credits	Marks
OE	18MA3T05		3-0-0	3	100

Objectives	The objective of this course is to classify, manufacturing, physical & mechanical properties and applications of a range of composite materials, and understand the mechanisms of composite deformation and fracture.
Pre-Requisites	Knowledge on materials science, metallurgy and mechanics of solids is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Definition, Classification and Characteristics of Composite materials, Advantages and application of composites, Functional requirements of reinforcement and matrix, Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance, Properties (mechanical, transport, thermal, etc.).	**8 Hours**
Module-2	**Reinforcements**: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers; Properties and applications of whiskers, particle reinforcements, Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures, Isostrain and Isostress conditions.	**8 Hours**
Module-3	**Manufacturing of Metal Matrix Composites**: Casting -– Solid State diffusion technique, Cladding – Hot isostatic pressing, Properties and applications; Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration — Liquid phase sintering; Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving, Properties and applications.	**9 Hours**
Module-4	**Manufacturing of Polymer Matrix Composites**: Preparation of moulding compounds and prepregs (hand layup method, Autoclave method, Filament winding method, Compression moulding, Reaction injection moulding), Properties and applications.	**8 Hours**
Module-5	**Failure of Composites**: Fracture modes in composites, Laminar Failure Criteria – strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure, Laminate first play failure-insight strength; Laminate strength – ply discount truncated maximum strain criterion, stress concentrations.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. W. D. Callister and D. G. Rethwisch, ***Materials Science and Engineering - An introduction***, 10th Edition, Wiley, 2014.
T2. K. K. Chawla, ***Composite Materials: Science and Engineering***, 3rd Edition, Springer, 2012.

Reference Books:

R1. R. F. Gibson, ***Principles of Composite Materials Mechanics***, 2nd Edition, CRC Press, 2007.
R2. B. Harris, ***Engineering Composite Materials***, 2nd Edition, Institute of Metals, 1999.
R3. R. W. Cahn, ***Material Science and Technology, Vol 13 -– Composites***, VCH, West Germany.

Online Resources:

1. https://nptel.ac.in/downloads/112104168/
2. http://www.issp.ac.ru/ebooks/books/open/Composites_and_Their_Properties.pdf
3. https://nptel.ac.in/courses/Webcourse-contents/IIScBANG/Composite%20Materials/pdf/Lecture_Notes/LNm7.pdf
4. https://nptel.ac.in/courses/Webcourse-contents/IISc-BANG/Composite%20Materials/pdf/Teacher_Slides/mod2.pdf

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Classify and know the properties & applications of composite materials.
CO2	Identify various reinforcing agents and mechanical behavior of composites.
CO3	Know the various manufacturing techniques used in development of metal matrix composites and their applications.
CO4	Recognize the various manufacturing techniques used in development of polymer matrix composites and their applications.
CO5	Understand the various fracture and failures modes of composite materials.

Program Outcomes Relevant to the Course:

PO6	Function effectively as an individual or as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.
PO8	Understand intellectual property rights and overall professional & ethical responsibility.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1						1		1	1	1	1		
CO2						1		1	1	1		1	1
CO3						1		1	1	1	1		1
CO4						1		1	1	1		1	1
CO5						1		1	1	1	1	1	1

Type	Code	Waste to Energy	L-T-P	Credits	Marks
OE	18MA3T06		3-0-0	3	100

Objectives	The objective of the course is to provide exposure to working principles of waste to energy schemes, their implementation & current practices, and understand the energy conversion technologies of biomass resources.
Pre-Requisites	Knowledge of engineering chemistry, engineering Physics, Thermodynamics environmental science, basic electrical engineering.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on recent trends & technologies.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to Energy from Waste: Classification of waste as fuel, Agro based, Forest residue, Industrial waste, MSW, Introduction to Conversion devices, Incinerators, gasifiers, digestors.	**6 Hours**
Module-2	Biomass Pyrolysis: Pyrolysis types, Manufacture, yields and application of charcoal, Manufacture of pyrolytic oils and gases, Biomass Thermo chemical conversion, Direct combustion.	**6 Hours**
Module-3	Biomass Gasification: Fixed bed system, Downdraft and updraft gasifiers, Fluidized bed gasifiers, Gasifier Design, construction and operation, Gasifier burner arrangement for thermal heating, Gasifier engine arrangement, Equilibrium and kinetic consideration in gasifier operation.	**9 Hours**
Module-4	Biomass Combustion: Biomass stoves, Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation of all the above biomass combustors.	**7 Hours**
Module-5	Biogas: Properties of biogas (Calorific value and composition), Biogas plant technology and status, Bio energy systems, Design and constructional features, Biomass resources and their classification, biochemical conversion, anaerobic digestion, Types of biogas Plants, Applications.	**8 Hours**
Module-6	Bioenergy & Biofuels: Alcohol production from biomass (ethanol), Bio diesel production, Urban waste to energy conversion, Biomass energy programme in India; Urban waste to energy conversion.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. A. V. Desai, ***Non Conventional Energy***, Wiley Eastern Ltd., 2011.
T2. K. C. Khandelwal and S. S. Mahdi, ***Biogas Technology: A Practical Hand Book***, Tata McGraw-Hill, 1989.
T3. P. Shilpkar and D. Shilpkar, ***Handbook Of Biogas Technology***, Agrotech Publishing, 2009.
T4. C. Y. W. Brobby and E. B. Hagan, ***Biomass Conversion and Technology***, Wiley-Blackwell, 1996.
T5. H. S. Mukunda, ***Understanding Clean Energy and Fuels from Biomass***, Wiley, 2011.

Reference Books:

R1. R. P. Overend, T. Milne, and L. Mudge, ***Fundamentals of Thermochemical Biomass Energy***, Springer, 2011.
R2. V. C. Nelson and K. L. Starcher, ***Introduction to Bioenergy (Energy and the Environment)***, 1st Edition, CRC Press, 2016.

Online Resources:

1. https://nptel.ac.in/downloads/112104168/
2. http://www.issp.ac.ru/ebooks/books/open/Composites_and_Their_Properties.pdf
3. https://nptel.ac.in/courses/Webcourse-contents/IIScBANG/Composite%20Materials/pdf/Lecture_Notes/LNm7.pdf
4. https://nptel.ac.in/courses/Webcourse-contents/IISc-BANG/Composite%20Materials/pdf/Teacher_Slides/mod2.pdf

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand biomass based resources.
CO2	Understand thermo chemical conversion process of biomass.
CO3	Understand the applications of biomass combustion process in energy conversion.
CO4	Study the design, analysis of biochemical conversion process of biomass.
CO5	Study the design of anaerobic energy conversion system for biomass.
CO6	Study the design of biomass energy conversion to biofuels (biodiesel, gasohol).

Program Outcomes Relevant to the Course:

PO1	Apply the knowledge of science and mathematics in analyzing and designing electronic & communication equipment for various industrial and domestic applications.
PO3	Develop robust and problem specific algorithms for processing, analysis, synthesis of signals, and exploring recent developments in the field of advanced communication engineering.
PO5	Design and conduct experiments, analyze and interpret data, utilize programming skills for development of simulation experiments.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.
PO7	Understand the impact of electronics & communications in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	1		1			2					2	1	
CO2	1		1			2					1	1	
CO3	1		1			2					1	1	1
CO4	1		1		1	2	2			1	2		1
CO5	1		1		1	2	2			1	2	1	1
CO6	1		1		1	2	2			1	1	1	1