R-25 Curriculum

for

M. Tech

in

Electronics & Communication Engineering

Department of Electronics & Communication Engineering

Narula Institute of Technology

81, Nilgunj Road

Kolkata 700109

1st Semester

Course Code	Type	Course Title	L	T	P	Credits	Total Hours
Theory							
MECE101	PC	Probability and Stochastic Processes	2	0	0	2	2
MECE102	PC	Advanced Digital Signal Processing	3	0	0	3	3
MECE103	PC	Low power VLSI design	3	0	0	3	3
MECE104	PE	A: Audio Coding & Compression B: Wireless Sensor Networks C: Analog VLSI circuit D: Pattern Recognition and Machine Learning	3	0	0	3	3
MECE105	PE	A: Cognitive Radio B: Remote Sensing C: Printing Wearable devices D: VLSI fabrication technology	3	0	0	3	3
MECE106	IPR	Research Methodology and IPR	2	0	0	2	2
MECE107	AUDIT1	English for Research Paper Writing	2	0	0	2	2
Lab							
MECE192	PC	Advanced Digital Signal Processing Lab	0	0	4	4	2
MECE194	PE	A: Audio Coding & Compression Lab B: Wireless Sensor Networks Lab C: Analog VLSI circuit Lab D: Pattern Recognition and Machine Learning Lab	0	0	4	4	2

2nd Semester

Course Code	Type	Course Title	L	T	P	Credits	Total Hours
Theory							
MECE201	PC	Coding & Cryptography	3	0	0	3	3
MECE202	PC	Advanced Electronic Design Automation	3	0	0	3	3
MECE203	PE	A: Deep Learning B: IOT C: Wireless & Mobile Communication D: Advanced semiconductor devices	3	0	0	3	3
MECE204	PE	A: MIMO System B: MEMS C: VLSI Design Verification and Testing D: Antennas and Radiating Systems	3	0	0	3	3
MECE205	AUDIT2	Pedagogy Studies	2	0	0	2	2
Lab							
MECE291	PC	Coding & Cryptography Lab	0	0	4	4	2
MECE293	PE	A: Deep Learning Lab B: IOT Lab C: Wireless & Mobile Comm. Lab D: Advanced Semiconductor devices Lab	0	0	4	4	2
Sessional							
MECE294	PROJECT & SEMINAR	Mini Project with Seminar	0	0	4	4	2

3rd Semester

Course Code	Type	Course Title	L	T	P	Credits	Total Hours
Theory							
MECE301	PE	A: High Performance Networks B: Optimization Techniques C: GIS D: Quantum Computing	3	0	0	3	3
MECE302	OE	A: Business Analytics B: Industrial Safety C: Operations Research D: Cost Management of Engineering Projects	3	0	0	3	3
Sessional							
MECE391	PROJECT & SEMINAR	Dissertation-I	0	0	20	10	20

4th Semester

Course Code	Type	Course Title	L	T	P	Credits	Total Hours
Sessional							
MECE391	PROJECT & SEMINAR	Dissertation-II	0	0	32	16	32

Course Name: Probability and Stochastic Processes

Course Code: MECE101
Contact: 2:0:0
Total Contact Hours: 25
Credit: 2

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

CO1: Explain the fundamental concepts of probability, random variables, and associated distributions for modelling random phenomena.

CO2: Apply the principles of joint, marginal, and conditional distributions to analyse relationships between multiple random variables.

CO3: Analyse the characteristics of random processes, including stationarity, ergodicity, and correlation functions, for signal modelling.

CO4: Interpret and compute spectral characteristics of random processes for understanding frequency-domain behaviour.

CO5: Utilise probabilistic tools and stochastic models to solve problems in communication, signal processing, and related engineering applications.

Module 1

Probability: Algebra of sets, Probability introduced through Sets and Relative Frequency, Discrete and Continuous Sample Spaces, Events, Probability Definitions and Axioms, Mathematical Model of Experiments, cumulative distribution functions, probability mass (density) functions, mathematical expectations, general concepts of conditional probability and expectation, conditional expectation given a sigma field, properties of conditional expectation, moments, moment and probability generating functions, moment inequalities: Markov, Chebyshev-Bienayme, Lyapunov. Probability as a Relative Frequency, Joint Probability, Conditional Probability, Total Probability, Bayes' Theorem, Independent Events.

Module 2

Multiple Random Variables: Vector Random Variables, Joint Distribution Function, Properties of Joint Distribution, Marginal Distribution Functions, Conditional Distribution and Density — Point Conditioning, Conditional Distribution and Density — Interval conditioning, Statistical Independence, Sum of Two Random Variables, Sum of Several Random Variables, Central Limit Theorem (Proof not expected), Unequal Distribution, Equal Distributions.

Module 3

Random Processes: The Random Process Concept, Classification of Processes, Distribution and Density Functions, concept of Stationarity and Statistical Independence, First-Order Stationary Processes, Second-Order and Wide-Sense Stationarity, (N-Order) and Strict-Sense Stationarity, Time Averages and Ergodicity, Mean-Ergodic Processes, Correlation-Ergodic Processes, Autocorrelation Function and Its Properties, Cross-Correlation Function and its Properties, Covariance Functions, Gaussian Random Processes, Poisson Random Process.

Module 4

Random Processes — Spectral Characteristics: The Power Spectrum — Properties, Relationship between Power Spectrum and Autocorrelation Function, The Cross-Power Density Spectrum — Properties, Relationship between Cross-Power Spectrum and Cross-Correlation Function.

References

1. Probability, Random Variables & Random Signal Principles, Peyton Z. Peebles, 4th Edition, Tata McGraw Hill, 2001.
2. Probability, Random Variables and Stochastic Processes, Athanasios Papoulis and S. Unnikrishna Pillai, 4th Edition, PHI, 2002.
3. Probability Theory and Stochastic Processes, P. Ramesh Babu, 1st Edition, McGraw Hill Education, 2014.
4. Probability Methods of Signal and System Analysis, George R. Cooper, Clave D. McGillem, 3rd Edition, Oxford, 1999.

CO–PO Mapping

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	1	2	2	-	-	-	1	1	-	2
CO2	3	3	2	2	2	-	-	-	1	1	-	2
CO3	3	3	2	3	2	-	-	-	1	1	-	2
CO4	3	2	2	2	2	-	-	-	1	1	-	2
CO5	3	3	3	2	3	1	1	1	2	2	1	3

Note: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not matched.

Course Name: Advanced Digital Signal Processing

Course code: MECE102
Contact: 3:0:0
Total contact Hours: 36
Credit: 3

Course Outcomes

At the end of this course, masters will be able to:

CO1: Understand the theoretical foundations of digital filters, transforms, and realization structures.

CO2: Apply concepts of multirate signal processing for efficient system design.

CO3: Analyze and design systems using linear prediction, optimum filters, and adaptive filtering algorithms.

CO4: Evaluate and implement spectral estimation methods for real-world signals.

CO5: Explore emerging DSP applications including wavelets, speech, radar, biomedical, and image processing.

Module 1: Review of DSP Fundamentals and Transforms

Discrete-time signals and systems, convolution, Z-transform, DFT and FFT algorithms (Radix-2, Radix-4), spectral analysis, circular convolution. Relevance of transforms in DSP.

Module 2: FIR and IIR Filter Design and Realizations

Design techniques of FIR filters: window methods, frequency sampling method, optimal equiripple design. IIR filter design: impulse invariance, bilinear transformation. Realization structures: direct form, cascade, parallel, lattice and lattice-ladder.

Module 3: Multirate Digital Signal Processing

Decimation and interpolation principles, sampling rate conversion, multistage decimators/interpolators, polyphase structures, quadrature mirror filters, filter banks, applications in subband coding.

Module 4: Linear Prediction and Optimum Filters

Stationary random processes, normal equations, forward-backward linear prediction, AR, MA, ARMA models. Wiener filtering for prediction and noise reduction.

Module 5: Adaptive Filtering Algorithms

Minimum mean-square error criterion, gradient adaptive lattice, LMS algorithm, normalized LMS, RLS algorithm. Applications: system identification, channel equalization, echo cancellation.

Module 6: Spectrum Estimation Techniques

Nonparametric methods: periodogram, Welch method, Bartlett method. Parametric methods: Yule-Walker, Burg's method, Pisarenko harmonic decomposition, MUSIC, ESPRIT.

Module 7: Applications and Emerging Topics in DSP

Wavelet transforms: continuous and discrete, multiresolution analysis. Applications in radar, speech processing, biomedical signal analysis, image processing, and communication systems.

References

- J.G. Proakis and D.G. Manolakis, *Digital Signal Processing: Principles, Algorithms and Applications*, 4th Edition, Prentice Hall, 2007.
- N. J. Fliege, *Multirate Digital Signal Processing: Multirate Systems - Filter Banks – Wavelets*, 1st Edition, John Wiley and Sons Ltd, 1999.
- Bruce W. Suter, *Multirate and Wavelet Signal Processing*, 1st Edition, Academic Press, 1997.
- M. H. Hayes, *Statistical Digital Signal Processing and Modeling*, John Wiley & Sons Inc., 2002.
- S. Haykin, *Adaptive Filter Theory*, 4th Edition, Prentice Hall, 2001.
- D.G. Manolakis, V.K. Ingle and S.M. Kogon, *Statistical and Adaptive Signal Processing*, McGraw Hill, 2000.

MCO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	1	2	-	-	-	1	1	-	2
CO2	3	3	3	2	3	1	1	1	2	2	1	3
CO3	3	3	3	2	2	-	-	-	1	1	-	2
CO4	3	3	3	2	3	1	-	1	2	2	1	2
CO5	3	3	2	2	3	1	1	1	1	2	1	3

Note: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not matched.

Course Name: Low Power VLSI Design

Course code: MECE103
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

Course Outcomes

At the end of this course, masters will be able to:

CO1: Understand the need for low-power VLSI design, sources of power dissipation, and emerging low power design approaches.

CO2: Analyze the impact of device scaling and technology innovations on power dissipation and explore circuit-level techniques for leakage power reduction.

CO3: Apply various simulation-based power analysis techniques at circuit, logic, and architectural levels for estimating and optimizing power consumption.

CO4: Design and implement low-power arithmetic circuits including adders and multipliers using advanced low-power design methodologies.

CO5: Explore low-power techniques for memory design and architectural optimizations to enhance power efficiency in VLSI systems.

Course Content

Module 1: Fundamentals

Basics of MOS circuits, Sources of Power Dissipation (Short-circuit Power, Switching Power, Glitching Power), Static Power Dissipation, Overview of Low-Power Design Concept along with Limitations.

Module 2: Supply Voltage Scaling Approaches

Device feature size scaling, Multi-Vdd Circuits, Architectural level approaches: Parallelism, Pipelining, Voltage scaling using high-level transformations, Dynamic voltage scaling, Power Management.

Module 3: Switched Capacitance Minimization Approaches

Hardware–Software Tradeoff, Bus Encoding, Two's complement vs Sign Magnitude, Architectural optimization, Clock Gating, Logic styles.

Module 4: Leakage Power Minimization Approaches

VTMOS Approach, MTMOS Approach, Power Gating, Transistor Stacking, DTCMOS.

Module 5: Basic Low Power Circuit Modules

Low Power Adder Design Techniques, Low Power Multiplier Design Techniques, Low Power SRAM Circuit Design Techniques, Low Power DRAM Circuit Design Techniques.

References

1. Sung-Mo Kang, Yusuf Leblebici, *CMOS Digital Integrated Circuits – Analysis and Design*, TMH, 2011.
2. Kiat Seng Yeo, Kaushik Roy, *Low Voltage, Low Power VLSI Subsystems*, Tata McGraw-Hill, 2012.
3. Rabaey, Pedram, *Low Power Design Methodologies*, Kluwer Academic.
4. Gary K. Yeap, *Practical Low Power Digital VLSI Design*, Kluwer Academic Publishers, 2002.

CO-PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	2	2	1	1			2	
CO2	2	3	3	2	2	1				2	
CO3	3	3	3	3	2		1			2	1
CO4	2	2	3	3	3		1			2	1
CO5	2	3	3	2	3	1				2	1

Note: 3 = Strong, 2 = Medium, 1 = Low, blank = No mapping.

Course Name: Audio Coding & Compression

Course Code: MECE104A
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

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

CO1: Explain the principles and algorithms used in lossy and lossless compression systems for multimedia data.

CO2: Apply image and video compression techniques, including motion estimation and transform coding, to real-world problems.

CO3: Evaluate and compare various video coding standards such as MPEG, H.26x series, and their applications.

CO4: Implement and analyse audio coding methods using transform, filter bank, and psychoacoustic models.

CO5: Design multimedia synchronization strategies for integrated audio–video systems with indexing and retrieval functionalities.

Module 1

Introduction to Multimedia Systems and Processing, Lossless Image Compression Systems, Huffman Coding, Arithmetic and Lempel-Ziv Coding, Other Coding Techniques.

Module 2

Lossy Image Compression Systems, Theory of Quantization, Delta Modulation and DPCM, Transform Coding & K-L Transforms, Discrete Cosine Transforms, Multi-Resolution Analysis, Theory of Wavelets, Discrete Wavelet Transforms, Still Image Compression Standards: JBIG and JPEG.

Module 3

Video Coding and Motion Estimation: Basic Building Blocks & Temporal Redundancy, Block-based motion estimation algorithms, Other fast search motion estimation algorithms.

Module 4

Video Coding Standards: MPEG-1, MPEG-2, MPEG-4, H.261, H.263, H.264.

Module 5

Audio Coding: Basics of Audio Coding, Transform and Filter Banks, Polyphase Filter Implementation, Audio Format and Encoding, Psychoacoustic Models.

Module 6

Multimedia Synchronization: Definitions and Requirements, Reference Models and Specifications, Time Stamping and Pack Architecture, Packet Architectures and Audio–Video Interleaving, Playback Continuity. Video Indexing and Retrieval: Content-Based Image Retrieval, Video Content Representation, Video Sequence Query Processing.

References

1. Iain E.G. Richardson, *H.264 and MPEG-4 Video Compression*, Wiley, 2003.
2. Khalid Sayood, *Introduction to Data Compression*, 4th Edition, Morgan Kaufmann, 2012.
3. Mohammed Ghanbari, *Standard Codecs: Image Compression to Advanced Video Coding*, 3rd Edition, The Institution of Engineering and Technology, 2011.
4. Julius O. Smith III, *Spectral Audio Signal Processing*, W3K Publishing, 2011.
5. Nicolas Moreau, *Tools for Signal Compression: Applications to Speech and Audio Coding*, Wiley, 2011.

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	3	-	-	-	1	1	-	2
CO2	3	3	3	2	3	1	-	-	2	2	1	3
CO3	3	3	3	3	3	1	1	1	2	2	1	3
CO4	3	2	3	3	3	1	-	-	2	2	1	2
CO5	3	2	3	2	3	1	1	1	2	3	2	3

Weightage Values: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not matched.

Course Name: Wireless Sensor Networks

Course Code: MECE104B
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

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

CO1: Design wireless sensor network architectures for various applications considering performance, cost, and environmental constraints.

CO2: Select and integrate appropriate sensors and hardware platforms for specific application needs.

CO3: Analyse and apply suitable radio standards and communication protocols for wireless sensor network deployment.

CO4: Implement and evaluate wireless sensor node programming using operating systems, languages, and simulation tools.

CO5: Address advanced issues such as energy efficiency, security, fault tolerance, and scalability in wireless sensor network design.

Module 1

Introduction and overview of sensor network architecture and its applications, comparison with Ad Hoc Networks, sensor node architecture with hardware and software details.

Module 2

Hardware examples: mica2, micaZ, telosB, cricket, Imote2, tmote, btnode, SunSPOT. Software (Operating Systems): TinyOS, MANTIS, Contiki, RetOS.

Module 3

Programming tools: C, nesC. Performance comparison of WSN simulation and experimental platforms such as ns-2, QualNet, Opnet.

Module 4

Sensor network protocols: Physical, MAC, and Network layer protocols, node discovery protocols, multi-hop and cluster-based protocols. Fundamentals of IEEE 802.15.4, Bluetooth, BLE, UWB.

Module 5

Data dissemination and processing; differences with other DBMS, data storage, query processing.

Module 6

Specialized features: energy efficiency, security, fault tolerance, localization, connectivity, topology, deployment mechanisms, coverage issues, sensor web/grid, open research issues, enabling technologies.

References

1. H. Karl and A. Willig, *Protocols and Architectures for Wireless Sensor Networks*, John Wiley & Sons, India, 2012.
2. C. S. Raghavendra, K. M. Sivalingam, and T. Znati (Eds.), *Wireless Sensor Networks*, Springer Verlag, 1st Indian reprint, 2010.

3. F. Zhao and L. Guibas, *Wireless Sensor Networks: An Information Processing Approach*, Morgan Kaufmann, 1st Indian reprint, 2013.

4. Yingshu Li, My T. Thai, Weili Wu, *Wireless Sensor Network and Applications*, Springer, 2008.

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	2	2	1	2	2	2	3
CO2	3	2	2	2	3	1	1	-	1	1	1	2
CO3	3	3	3	3	3	2	1	1	2	2	1	3
CO4	3	2	3	3	3	1	-	-	2	2	1	2
CO5	3	3	3	3	3	3	3	2	2	2	2	3

Weightage Values: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not matched.

Course Name: Analog VLSI Circuits

Course code: MECE104C
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

Course Outcomes

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

CO1: Explain MOSFET models, device parameters, and noise fundamentals relevant to analog CMOS circuit design.

CO2: Design and analyze single-stage amplifiers and current mirrors, evaluating their performance, biasing, and noise characteristics.

CO3: Develop differential amplifier circuits and assess their common-mode response, mismatch effects, and input offset voltage.

CO4: Apply feedback techniques to analog circuits, and analyze their impact on stability, noise, and performance.

CO5: Design, simulate, and evaluate CMOS operational amplifiers and OTAs, including frequency response, compensation, common-mode feedback, and noise/distortion analysis.

Course Contents

Module I: Fundamentals of Analog CMOS Circuit Design

Motivation for analog VLSI and mixed signal circuits in CMOS technologies and issues thereof, MOSFET parameters; MOSFET I-V characteristics; MOSFET models (small-signal, large-signal, and high-frequency); Body effects in MOSFET; MOS device capacitances; Noise fundamentals; Noise in MOSFETs.

Module II: Single Stage Amplifiers

Design and noise analysis of single-stage amplifiers (Common source amplifier, source degeneration, source follower, common gate amplifier); Various performance parameters; Biasing techniques; Cascode stages.

Module III: Current Mirrors, Current and Voltage Reference

Basic current mirrors, cascode current mirrors, active current mirrors, low current biasing, band gap reference, supply insensitive biasing, temperature insensitive biasing, impact of device mismatch.

Module IV: Differential Amplifiers

Basic differential pair, common mode response, differential pair with MOS loads, Gilbert Cell, device mismatch effects, input offset voltage.

Module V: Feedback & Noise

Feedback topologies, effect of load, modelling input and output ports in feedback circuits. Statistical characteristics, types of noise, single stage amplifiers, differential pair, noise bandwidth, impact of feedback on noise.

Module VI: CMOS Operational Amplifiers

Basic CMOS operational amplifier; Operational transconductance amplifier (OTA); Performance parameters; Two-stage opamp; Specification based opamp design; Frequency response; feedback and stability; phase margin; Frequency compensation; Nonlinearity; Offset; Mismatches; Noise analysis; Distortion. Fully differential operational amplifier design; Various topologies and analysis; Common-mode feedback circuits.

Textbooks / References

1. Razavi, *Design of Analog CMOS Integrated Circuits*, McGraw-Hill, 2nd Ed., 2017.
2. Allen and Holberg, *CMOS Analog Circuit Design*, Oxford, 3rd Ed., 2016.
3. Carusone, Johns, and Martin, *Analog Integrated Circuit Design*, Wiley, 2013.
4. Gray, P.R., Hurst, P. J., Lewis, S.H., Meyer, R.G., *Analysis and Design of Analog Integrated Circuits*, 4th Ed., John Wiley and Sons, 2001.
5. Baker, R. J., Li, H. W. and Boyce, D. E., *CMOS Circuit Design, Layout and Simulation*, Prentice-Hall of India, 1998.

Course Name: Pattern Recognition and Machine Learning

Course Code: MECE104D
Contact: 3:0:0
Total Contact Hours: 34
Credit: 3

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

CO1: Apply linear algebra, probability theory, and optimization principles to machine learning problems.

CO2: Develop regression and classification models using probabilistic and discriminative learning techniques.

CO3: Implement dimensionality reduction, clustering, and non-metric classification methods for data analysis.

CO4: Evaluate machine learning algorithms in terms of accuracy, complexity, and generalization performance.

CO5: Integrate ensemble methods and advanced pattern recognition techniques in solving real-world problems.

Module 1

Basics of Linear Algebra, Probability Theory and Optimization: Vectors, Inner product, Outer product, Inverse of a matrix, Eigenanalysis, Singular value decomposition, Probability distributions – Discrete and Continuous; Independence, Conditional and Joint probability, Bayes theorem, Unconstrained and constrained optimization (Lagrangian multiplier method).

Module 2

Methods for Function Approximation: Linear models for regression, Parameter estimation (Maximum likelihood, Maximum a posteriori), Regularization, Ridge regression, Lasso, Bias-Variance decomposition, Bayesian linear regression.

Module 3

Probabilistic Models for Classification: Bayesian decision theory, Bayes classifier, Minimum error-rate classification, Gaussian discriminant functions, Gaussian mixture models, Expectation-Maximization, Naive Bayes classifier, Non-parametric density estimation, Hidden Markov models.

Module 4

Discriminative Learning Models: Logistic regression, Perceptron, Multilayer neural networks, Gradient descent, Backpropagation, Support vector machines.

Module 5

Dimensionality Reduction: Principal component analysis, Fisher discriminant analysis, Multiple discriminant analysis.

Module 6

Non-Metric Methods: Decision trees, CART.

Module 7

Ensemble Methods: Bagging, Boosting, Gradient boosting.

Module 8

Pattern Clustering: Clustering criteria, K-means, Hierarchical clustering, Density-based clustering, Spectral clustering, Cluster validation.

Text Books

1. C.M. Bishop, *Pattern Recognition and Machine Learning*, Springer.
2. R.O. Duda, P.E. Hart, D.G. Stork, *Pattern Classification*, John Wiley.

Reference Books

1. S. Theodoridis, K. Koutroumbas, *Pattern Recognition*, Academic Press.
2. E. Alpaydin, *Introduction to Machine Learning*, Prentice-Hall of India.
3. G. James, D. Witten, T. Hastie, R. Tibshirani, *Introduction to Statistical Learning*, Springer.

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	-	-	-	1	2	-	3
CO2	3	3	3	3	3	1	-	-	2	3	1	3
CO3	3	3	3	3	3	1	1	-	2	2	1	3
CO4	3	3	3	3	3	1	-	-	2	3	1	3
CO5	3	3	3	3	3	2	1	1	3	3	2	3

Weightage Values: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not matched.

Course Name: Cognitive Radio

Course code: MECE105A
Contact: 3:0:0
Total contact Hours: 36
Credit: 3 **Course Outcomes:** At the end of this course, masters will be able to:

CO1: Explain the architecture, functionalities, and potential applications of cognitive radio networks and dynamic spectrum access.

CO2: Design and implement spectrum sensing techniques, including energy detection, autocorrelation-based and cooperative methods, to detect and characterize spectrum holes.

CO3: Analyze spectrum sharing and allocation methods for TV white spaces and other bands using optimization and learning-based approaches to maximize spectral efficiency.

CO4: Evaluate dynamic spectrum access mechanisms, radio-resource management strategies, and spectrum trading models, including auction-based pricing and policy considerations.

CO5: Identify current research challenges in cognitive radio networks—such as cross-layer design, security, and scalability—and propose viable solutions.

Module 1: Introduction to Cognitive Radios

Digital dividend, cognitive radio (CR) architecture, functions of cognitive radio, dynamic spectrum access (DSA), components of cognitive radio, spectrum sensing, spectrum analysis and decision, potential applications of cognitive radio.

Module 2: Spectrum Sensing

Detection of spectrum holes (TVWS): Energy detection technique, autocorrelation based spectrum sensing, collaborative sensing, geo-location database and spectrum sharing business models (spectrum of commons, real time secondary spectrum market).

Module 3: Optimization Techniques of Dynamic Spectrum Allocation

Linear programming, convex programming, non-linear programming, integer programming, dynamic programming, stochastic programming.

Module 4: Dynamic Spectrum Access and Management

Spectrum broker, cognitive radio architectures, centralized dynamic spectrum access, distributed dynamic spectrum access, learning algorithms and protocols.

Module 5: Spectrum Trading

Introduction to spectrum trading, classification to spectrum trading, radio resource pricing, brief discussion on economics theories in DSA (utility, auction theory), classification of auctions (single auctions, double auctions, concurrent, sequential).

Module 6: Research Challenges in Cognitive Radio

Network layer and transport layer issues, cross-layer design in cognitive radio networks.

References

- Ekram Hossain, Dusit Niyato, Zhu Han, *Dynamic Spectrum Access and Management in Cognitive Radio Networks*, Cambridge University Press, 2009.
- Kwang-Cheng Chen, Ramjee Prasad, *Cognitive Radio Networks*, John Wiley & Sons Ltd., 2009.
- Bruce Fette, *Cognitive Radio Technology*, Elsevier, 2nd Edition, 2009.
- Huseyin Arslan, *Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems*, Springer, 2007.
- Francisco Rodrigo Porto Cavalcanti, Soren Andersson, *Optimizing Wireless Communication Systems*, Springer, 2009.
- Linda Doyle, *Essentials of Cognitive Radio*, Cambridge University Press, 2009.

CO–PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	-	-	-	2	-	2
CO2	3	3	3	3	3	1	-	-	-	2	-	2
CO3	3	3	3	3	3	2	1	-	-	2	-	3
CO4	3	3	3	3	3	2	1	-	-	3	1	3
CO5	3	2	2	3	2	2	2	1	-	3	1	3

Weightage Values: 3 = Strongly matched, 2 = Moderately matched, 1 = Weakly matched, (-) = Not matched.

Course Name: Remote Sensing

Course Code: MECE105B
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

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

CO1: Explain the principles of electromagnetic wave propagation and atmospheric interactions in the context of remote sensing.

CO2: Describe the components, functionalities, and types of remote sensing systems, including various satellite platforms.

CO3: Apply remote sensing concepts to analyze spatial, spectral, radiometric, and temporal data for environmental and geospatial studies.

CO4: Interpret remote sensing data using visual and digital processing techniques for thematic mapping and analysis.

CO5: Evaluate advanced remote sensing technologies, including thermal and hyperspectral sensing, for diverse applications.

Module 1: Physics Of Remote Sensing

Electro Magnetic Spectrum, physics of remote sensing, effects of atmosphere – scattering (different types), absorption, 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.

Module 2: Reflectivity and Radiation Characteristics

Variation of the earth's reflectivity with angle of incidence, wavelength and geographical location; seasonal variation of reflectivity; solar radiation reflected from the earth; absorption of solar radiation by the earth; thermal radiation from the earth; thermal radiation from atmospheric constituents; thermal emission from cloud, rain, snow and fog; radio noise and interference at satellite heights.

Module 3: Remote Sensing Satellites

Orbits of remote sensing satellites; remote sensing satellites – LANDSAT, GPS, GNSS, GLONASS, Upper Atmosphere Research Satellites (UARS), INSAT, NOAA.

Module 4: Sensors and Imaging Systems

Photographic products – B/W, color, color IR film and their characteristics; resolving power of lens and film. Opto-mechanical and electro-optical sensors – across track and along track scanners, multispectral scanners and thermal scanners, geometric characteristics of scanner imagery, calibration of thermal scanners.

Module 5: Data Analysis and Processing

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.

Module 6: Thermal and Hyperspectral Remote Sensing

Sensor 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.

References:

1. Jensen, J.R., *Remote Sensing of the Environment: An Earth Resource Perspective*, Prentice Hall, 2000.
2. Joseph George, *Fundamentals of Remote Sensing*, Universities Press, 2003.
3. D.C. Agarwal, *Satellite Communication*, Khanna Publishers.
4. R.P. Gupta, *Remote Sensing Geology*, Springer, 1990.
5. Anji Reddy, M., *Geoinformatics for Environmental Management*, B.S. Publications, 2004.

CO–PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	-	-	-	2	-	2
CO2	3	3	3	3	3	2	-	-	-	2	-	2
CO3	3	3	3	3	3	2	2	1	-	3	-	3
CO4	3	3	3	3	3	2	2	1	-	3	1	3
CO5	3	3	3	3	3	2	3	1	-	3	1	3

Course Name: Printing Wearable Devices

Course Code: MECE105C
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

Course Outcomes

At the end of this course, masters will be able to:

CO1: Understand the fundamentals and materials used in printing wearable devices.

CO2: Apply 3D printing and flexible electronics techniques to fabricate wearable devices.

CO3: Analyze design requirements and optimize wearable device performance.

CO4: Implement sensors and actuators integration into wearable platforms.

CO5: Evaluate real-world applications and challenges of wearable device technologies.

Course Contents

Unit 1: Introduction to Wearable Devices

Overview of wearable electronics; history and evolution; types of wearable devices (health monitoring, sports, fashion, industrial applications); introduction to smart textiles and flexible electronics; challenges in design and fabrication; safety and ethical considerations.

Unit 2: Materials for Wearable Devices

Conductive polymers, flexible substrates, inks and nanoparticles; biocompatible and stretchable materials; sensors and actuator materials; mechanical, thermal, and electrical properties of materials for wearable devices; material selection criteria for different applications.

Unit 3: Fabrication and Printing Techniques

3D printing of wearable electronics; inkjet, screen, and aerosol jet printing; roll-to-roll and additive manufacturing processes; lithography and laser-based techniques; fabrication of flexible circuits; integration of electronics with textiles.

Unit 4: Design and Optimization

Design principles for wearable devices; ergonomic and human-centered design; power management and energy harvesting; miniaturization of circuits; thermal management; simulation tools for device design; reliability and durability testing.

Unit 5: Sensors and Actuators Integration

Types of sensors used in wearable devices: physiological, environmental, motion sensors; actuator technologies; interfacing sensors with flexible circuits; wireless data transmission; signal conditioning and processing; data collection and interpretation.

Unit 6: Applications and Case Studies

Healthcare monitoring devices, sports and fitness trackers; smart clothing; industrial and military applications; challenges in commercialization; future trends in wearable technology; case studies on innovative wearable devices.

Unit 7: Testing, Evaluation, and Standards

Evaluation of device performance, reliability, and safety; mechanical, electrical, and environmental testing; regulatory standards and certifications; user studies and feedback incorporation; scalability and manufacturing considerations.

References

1. Stoppa, M., & Chiolerio, A. (2014). Wearable electronics and smart textiles: a critical review. *Sensors*, 14(7), 11957–11992.
2. He, Y., et al. (2019). 3D Printing of Flexible and Wearable Electronics. *Advanced Materials Technologies*, 4(7), 1800625.
3. Trung, T. Q., & Lee, N. E. (2017). Flexible and Stretchable Physical Sensor Integrated Platforms for Wearable Human-Activity Monitoring and Personal Healthcare. *Advanced Materials*, 29(22), 1603167.
4. Kwon, O. S., et al. (2017). Wearable and Stretchable Electronics for Healthcare Applications. *Advanced Healthcare Materials*, 6(23), 1700175.
5. Cherenack, K., & van Pieterson, L. (2012). Smart textiles: Challenges and opportunities. *Journal of Applied Physics*, 112(9), 091301.

CO-PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	2	1	2	1	1	2	2
CO2	3	3	2	2	2	2	2	2	2	2	2	3
CO3	3	2	3	2	2	2	1	2	2	2	2	2
CO4	2	3	3	3	2	1	1	2	2	2	2	2
CO5	3	2	3	3	3	2	2	2	2	2	3	3

Note: Scale – 3 = Strong, 2 = Medium, 1 = Slight.

Paper Name: VLSI Fabrication Technology

Paper Code: MECE105D
Credit: 3
Total Contact: 36

Course Outcomes

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

CO1: Explain the principles of crystal growth, wafer preparation, and cleanroom practices essential for VLSI fabrication.

CO2: Analyze oxidation processes, oxide properties, and device isolation techniques for reliable semiconductor device fabrication.

CO3: Apply lithography and etching techniques, including advanced methods, for high-resolution pattern transfer in IC manufacturing.

CO4: Evaluate diffusion and ion implantation processes, including profiles, damage mechanisms, and annealing for dopant control.

CO5: Compare and implement thin film deposition and metallization techniques for interconnect formation, planarization, and reliability enhancement in VLSI circuits.

Course Modules

Module I: Crystal Growth and Wafer Preparation

Crystal structure and properties, Starting with raw materials, Growth of Single crystal silicon - Czochralski and Float zone method, Dopant distribution, Bridgman Technique, crystal defects, Wafer processing, Concepts of Wafer cleaning processes, Concepts of Clean room and safety requirements.

Module II: Oxidation

Purpose of oxidation, Growth mechanism and Kinetics of oxidation for thick, thin and ultra-thin films, Oxidation techniques and systems in VLSI and ULSI, Oxide properties, Oxide charges, Oxide thickness characterization, High k and low k dielectrics for ULSI, Device isolation techniques (LOCOS and STI).

Module III: Lithography

Overview of lithography, Photolithography, Optical exposure methods, Masks, Photoresist, Pattern transfer, Anisotropic and isotropic etching, Etch profiles, Etch mechanism, Common etchants, Plasma Etching, Reactive Ion Etching, Resolution enhancement, Advanced Lithography-Electron lithography, X-ray lithography.

Module IV: Diffusion & Ion Implantation

Fick's law, Lateral diffusion, Diffusion profiles, Two-step diffusion, Diffusion in Polysilicon and SiO_2, Ion implantation, Implanted ions profile, Advantage and problem of Ion implantation, implantation damage, Annealing, Ion channeling, Tilt-angle ion implantation, High energy implantation.

Module V: Thin Film Deposition

Physical Vapor Deposition: Thermal evaporation, Electron beam evaporation, Sputtering. Chemical Vapor Deposition (CVD): Advantages and disadvantages of CVD techniques over PVD techniques, CVD techniques-APCVD, LPCVD, Metalorganic CVD (MOCVD), Plasma Enhanced CVD, Liquid phase epitaxy, Vapor phase epitaxy, Molecular beam epitaxy, Heteroepitaxy.

Module VI: Metallisation

Overview of Interconnects, Contacts, Metal gate/Poly Silicon Gate, Problems in Aluminium Metal contacts, Al spike, Electromigration, Failure mechanisms in metal interconnects, multi-level metallization schemes, Metal Silicide, Planarization, Inter metal dielectric.

Textbooks/References

1. S.M. Sze, "VLSI Technology", 2nd Edition, McGraw Hill Companies Inc.
2. C.Y. Chang and S.M. Sze, "ULSI Technology", McGraw Hill Companies Inc.
3. Stephena Campbell, "The Science and Engineering of Microelectronic Fabrication", Second Edition, Oxford University Press.
4. James D. Plummer, Michael D. Deal, "Silicon VLSI Technology", Pearson Education.
5. S. K. Gandhi, "VLSI Fabrication principles", Wiley.
6. J.P Colinge, "Silicon-On-Insulator Technology: Materials to VLSI", 3rd ed., Springer, 2004.

Course Name: Research Methodology and IPR

Course code: MECE106
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

Course Outcomes

At the end of this course, Masters will be able to:

CO1: Understand research problem formulation.

CO2: Analyse research related information.

CO3: Develop understanding that today's world is controlled by Computer, Information Technology, but tomorrow's world will be ruled by ideas, concepts, and creativity.

CO4: Understand the significance of Intellectual Property Rights (IPR) for individual and national growth.

CO5: Apply research methodology and IPR knowledge in practical scenarios and case studies.

Course Contents

Unit 1: Research Problem Formulation

Meaning of research problem, sources of research problem, criteria and characteristics of a good research problem, common errors in selecting a research problem, scope and objectives. Approaches for investigation, data collection, analysis, interpretation, and necessary instrumentation.

Unit 2: Literature Review and Research Ethics

Effective literature study approaches, analysis, plagiarism, and research ethics.

Unit 3: Technical Writing and Research Proposal

Effective technical writing, report writing, paper preparation, developing a research proposal, format of research proposal, presentation, and assessment by a review committee.

Unit 4: Intellectual Property Fundamentals

Nature of Intellectual Property: patents, designs, trade and copyright. Process of patenting and development: technological research, innovation, patenting, development. International scenario: cooperation on intellectual property. Procedures for granting patents, Patenting under PCT.

Unit 5: Patent Rights and Technology Transfer

Scope of patent rights, licensing, and transfer of technology. Patent information and databases. Geographical indications.

Unit 6: New Developments in IPR

Administration of patent system, new developments in IPR, IPR of biological systems, computer software, traditional knowledge. Case studies and IPR activities in IITs.

References

1. Stuart Melville and Wayne Goddard, *Research Methodology: An Introduction for Science & Engineering Students*.
2. Wayne Goddard and Stuart Melville, *Research Methodology: An Introduction*.
3. Ranjit Kumar, 2nd Edition, *Research Methodology: A Step-by-Step Guide for Beginners*.
4. Halbert, *Resisting Intellectual Property*, Taylor & Francis Ltd, 2007.
5. Mayall, *Industrial Design*, McGraw Hill, 1992.
6. Niebel, *Product Design*, McGraw Hill, 1974.

CO-PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	1	1	1	2	2	2	2
CO2	3	3	2	2	2	1	1	1	2	2	2	2
CO3	2	3	3	2	3	2	2	2	2	2	3	3
CO4	3	2	3	3	3	1	1	2	3	2	2	3
CO5	3	3	3	3	3	2	2	2	2	2	3	3

Note: Scale – 3 = Strong, 2 = Medium, 1 = Slight.

Course Name: Advanced Digital Signal Processing Lab

Course Code: MECE192
Contact: 0:0:4
Credit: 2

Course Outcomes

At the end of this course, masters will be able to:

CO1: Generate and manipulate discrete-time signals, and analyze their behavior using convolution and transforms.

CO2: Design and implement FIR and IIR digital filters, and evaluate their performance in the frequency domain.

CO3: Implement multirate DSP techniques including decimation, interpolation, and filter banks for practical applications.

CO4: Apply linear prediction, adaptive filtering algorithms, and spectral estimation methods to real-world data.

CO5: Utilize wavelet transforms and multiresolution analysis for advanced DSP applications such as denoising and compression.

Laboratory Experiments

1. Generate discrete-time signals (impulse, step, ramp, sinusoidal, exponential) and perform convolution to verify linear time-invariant (LTI) system properties.
2. Compute and compare the DFT of a sequence using direct computation and FFT algorithms (Radix-2 and Radix-4) in MATLAB.
3. Design and implement FIR filters using window methods (Rectangular, Hamming, Blackman) and analyze their frequency responses.
4. Design and implement IIR filters using impulse invariance and bilinear transformation methods; compare their performances.
5. Implement multirate signal processing: decimation, interpolation, and sampling rate conversion using polyphase structures.
6. Design and analyze quadrature mirror filter banks for subband coding of audio signals.
7. Implement linear prediction algorithms to model signals and verify the solution of normal equations using Levinson–Durbin recursion.
8. Implement adaptive filters (LMS, NLMS, RLS) for applications such as noise cancellation or channel equalization.
9. Estimate power spectral density of signals using nonparametric methods (periodogram, Bartlett, Welch) and parametric methods (Yule-Walker, Burg's).
10. Apply discrete wavelet transform (DWT) for multi-resolution analysis and signal denoising in speech or image data.

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	2	-	-	-	1	1	-	2
CO2	3	3	2	3	3	-	-	-	1	1	-	2
CO3	3	3	2	3	3	-	-	-	1	1	-	2
CO4	3	3	3	3	3	1	-	-	1	1	1	3
CO5	3	3	3	3	3	1	1	1	2	2	1	3

Note: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not matched.

Course Name: Audio Coding & Compression Lab

Course code: MECE194A
Contact: 0:0:4
Credit: 2

Course Outcomes

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

CO1: Analyze and implement basic audio signal processing techniques such as quantization, delta modulation, PCM, and DPCM.

CO2: Apply lossless compression algorithms including Huffman coding and Shannon–Fano for efficient data representation.

CO3: Implement and evaluate denoising and filtering techniques for audio and video signals.

CO4: Design and analyze image and video compression techniques including JPEG and MPEG standards.

CO5: Apply motion estimation and background subtraction techniques for video analysis and real-time applications.

Course Contents

1. Study of Signal-to-Quantization Noise Ratio (SQNR) of audio signals.
2. Study of Delta Modulation.
3. Implementation of denoising techniques for audio signals using filters.
4. Study and design of Pulse Code Modulation (PCM) systems.
5. Study and design of Differential PCM (DPCM) systems.
6. Study of Huffman coding and decoding.
7. Implementation of Shannon–Fano algorithm.
8. Implementation of denoising techniques for video signals.
9. Implementation of foreground detection using background subtraction techniques.
10. Study and design of JPEG compression algorithm.
11. Motion vector estimation.
12. Study and design of video compression with MPEG-1 standard.
13. Innovative experiment.

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	-	-	-	1	1	-	2
CO2	3	3	3	3	3	-	-	-	1	1	-	2
CO3	3	3	3	3	3	-	-	-	1	1	-	3
CO4	3	3	2	3	3	1	-	-	1	1	1	3

Note: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not matched.

Course Name: Wireless Sensor Networks Lab

Course code: MECE194B
Contact: 0:0:4
Credit: 2

Course Outcomes

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

CO1: Illustrate observations gathered by individual sensor nodes and analyze their collective behavior in the network.

CO2: Identify and compare different Wireless Sensor Network platforms and protocols.

CO3: Implement and demonstrate WSN functionalities using embedded C and socket programming.

CO4: Design, develop, and evaluate wireless sensor nodes and communication protocols.

CO5: Apply simulation tools (e.g., NS) to model, analyze, and optimize performance of wireless sensor networks.

Course Contents

1. Implementation of Error Detection / Error Correction Techniques.
2. Implementation of Stop and Wait Protocol and Sliding Window.
3. Implementation and study of Go-Back-N and Selective Repeat protocols.
4. Implementation of High Level Data Link Control.
5. Study of Socket Programming and Client–Server model.
6. Write a socket program for Echo / Ping / Talk commands.
7. Create scenario and study the performance of network with CSMA / CA protocol and compare with CSMA / CD protocols.
8. Network Topology – Star, Bus, Ring.
9. Implementation of Distance Vector Routing Algorithm.
10. Implementation of Link State Routing Algorithm.
11. Study of Network Simulator (NS) and simulation of Congestion Control Algorithms using NS.
12. Encryption and decryption.
13. Innovative experiment.

Experiments Beyond Syllabus

1. Implementing a wireless sensor network.
2. Simulate a Mobile Adhoc Network.
3. Implement Transport Control Protocol in Sensor Network.

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	-	-	-	1	1	-	2
CO2	3	3	3	2	3	-	-	-	1	1	-	2
CO3	3	3	3	3	3	-	-	-	1	1	-	3
CO4	3	3	3	3	3	1	-	-	1	1	1	3
CO5	3	3	3	3	3	-	-	-	2	2	-	3

Note: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not matched.

Paper Name: Analog VLSI Circuits Lab

Paper Code: MECE194C
Contact: 0:0:4
Credit: 2

Course Outcomes

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

CO1: Demonstrate the ability to characterize NMOS and PMOS devices by extracting key parameters such as transconductance and output resistance and analyze their dependence on gate voltage and aspect ratio.

CO2: Design, simulate, and evaluate single-stage amplifiers (Common Source and Common Drain) and analyze their frequency response characteristics for gain, bandwidth, and stability.

CO3: Develop current mirror circuits (Cascade and Cascode) using MOS transistors and assess their performance improvements in terms of output resistance and current matching accuracy.

CO4: Design and simulate advanced amplifier topologies such as Differential Amplifier, OTA, and CMOS Op-Amp, and investigate their frequency response and practical limitations.

CO5: Apply the principles of analog VLSI design to implement and analyze fully differential operational amplifiers, emphasizing common-mode rejection, noise reduction, and high-frequency performance.

List of Experiments

1. Characterization of NMOS & PMOS Transistors and determination of transconductance and output resistance, Plot the variation of transconductance with gate voltage for different aspect ratios.
2. Design and Simulation of Common Source Amplifier and study of frequency response characteristics.
3. Design and Simulation of Common Drain Amplifier and study of frequency response characteristics.
4. Design and Simulation of Cascade and Cascode Current Mirror.
5. Design and Simulation of Differential Amplifier and study of frequency response characteristics.
6. Design and Simulation of Operational Transconductance Amplifier and study of frequency response characteristics.
7. Design and Simulation of CMOS Op-Amp and study of frequency response characteristics.
8. Design and Simulation of Fully Differential Operational Amplifier.

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	-	-	-	-	-	-	-
CO2	3	3	3	2	3	-	-	-	-	-	-	-
CO3	3	3	3	2	2	-	-	-	-	-	-	-
CO4	3	2	3	3	3	-	-	-	-	-	-	-
CO5	3	2	3	3	3	-	-	-	-	-	-	-

Note: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not matched.

Course Name: Pattern Recognition and Machine Learning Lab

Course code: MECE194D
Contact: 0:0:4
Credit: 2

Course Outcomes

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

CO1: Apply regression techniques on real datasets and analyze bias–variance trade-off.

CO2: Perform feature selection and feature extraction using statistical and dimensionality reduction methods.

CO3: Design and implement supervised classifiers such as logistic regression, decision trees, Naïve Bayes, KNN, and SVM.

CO4: Implement clustering algorithms and neural networks to analyze and classify datasets.

CO5: Evaluate model performance using training/testing accuracy and study advanced concepts such as curse of dimensionality and cluster validation.

Course Contents (Lab Experiments)

1. Take a suitable dataset and study linear regression with one variable and multiple variables.
2. Study the effect of bias and variance in linear regression.
3. Take a suitable dataset and select the good features using filter and wrapper methods.
4. Take a suitable dataset and extract the features using PCA.
5. Take a suitable dataset and design a classifier using:
    - Logistic Regression
    - Decision Trees
    - Naïve Bayes Classifier
    - KNN
    - SVM
6. Take a suitable dataset and cluster the data using K-means.
7. Take a suitable dataset, design ANN-based classifier and study the following:
    - Effect of single layer vs. multilayer
    - Effect of number of nodes in a layer
8. Take a suitable dataset to illustrate the importance of training and test accuracy in supervised learning.
9. Take a suitable dataset to show the curse of dimensionality and its solution using Sammon mapping.
10. For a given dataset, estimate the number of possible clusters using Silhouette method.
11. Innovative experiment.

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	-	-	-	1	1	-	2
CO2	3	3	3	2	3	-	-	-	1	1	-	2
CO3	3	3	3	3	3	-	-	-	1	2	-	3
CO4	3	3	3	3	3	1	-	-	2	2	1	3
CO5	3	3	3	3	3	-	-	-	2	2	-	3

Note: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not matched.

Course Name: Cryptography and Coding

Course code: MECE201
Contact: 3:0:0
Credit: 3

Course Outcomes

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

CO1: Explain the fundamental concepts of cryptography, modular arithmetic, and classical ciphers.

CO2: Analyze and compare symmetric encryption algorithms including stream ciphers, DES, and AES.

CO3: Apply mathematical foundations to understand and implement RSA cryptosystem.

CO4: Demonstrate the working principles of elliptic curve cryptography and compare with RSA.

CO5: Evaluate cryptographic algorithms in terms of security, efficiency, and real-world applications.

Course Contents

Module 1: Foundations of Cryptography

Introduction to cryptography and data security, symmetric cryptography basics, classical ciphers (Substitution, Shift, Affine), modular arithmetic, cryptanalysis, applications.

Module 2: Stream Ciphers

Stream vs. block ciphers, random numbers, one-time pad, LFSRs, Trivium, stream cipher attacks, implementation aspects.

Module 3: Block Ciphers – DES and Alternatives

Confusion and diffusion, DES algorithm and structure, key schedule, decryption, DES security, DES alternatives (3DES, PRESENT, AES overview).

Module 4: Advanced Encryption Standard (AES)

AES algorithm, Galois fields, internal structure (SubBytes, MixColumns, Key Schedule), encryption/decryption, implementation in hardware/software, comparison with DES.

Module 5: RSA Cryptosystem

Basics of public-key cryptography, RSA encryption/decryption, key generation and correctness, fast exponentiation, CRT, prime generation, RSA padding, attacks, applications.

Module 6: Elliptic Curve Cryptography

Elliptic curve definition and group operations, discrete logarithm problem with elliptic curves, ECC-based Diffie–Hellman, ECC security, ECC in practice, comparison with RSA.

References

1. William Stallings, *Cryptography and Network Security: Principles and Practice*, 7th Edition, Pearson, 2017.

2. Behrouz A. Forouzan, Debdeep Mukhopadhyay, *Cryptography and Network Security*, 3rd Edition, McGraw-Hill, 2015.

3. Alfred J. Menezes, Paul C. van Oorschot, Scott A. Vanstone, *Handbook of Applied Cryptography*, CRC Press, 1996.

4. Bruce Schneier, *Applied Cryptography: Protocols, Algorithms, and Source Code in C*, 2nd Edition, Wiley, 1996.

5. Christof Paar, Jan Pelzl, *Understanding Cryptography: A Textbook for Students and Practitioners*, Springer, 2010.

6. Johannes A. Buchmann, *Introduction to Cryptography*, 2nd Edition, Springer, 2004.

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	-	-	-	1	1	-	2
CO2	3	3	3	3	3	-	-	-	1	2	-	3
CO3	3	3	3	3	3	1	-	-	2	2	1	3
CO4	3	3	3	3	3	-	-	-	2	2	-	3
CO5	3	3	3	3	3	1	-	-	2	2	1	3

Note: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not matched.

Course Name: Advanced Electronic Design Automation

Course code: MECE202
Contact: 3:0:0
Credit: 3

Course Outcomes

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

CO1: Understand the behavioral modeling of system design and differentiate between simulation and modeling in the chip flow process.

CO2: : Implement advanced design methodologies using Verilog, including synthesizable constructs, timing analysis, and test bench creation for combinational and sequential logic.

CO3: Utilize SystemVerilog for the verification of RTL, emphasizing layered testbench architecture and applying constraint random verification methodologies.

CO4: Develop and manage complex verification environments using the Universal Verification Methodology (UVM).

CO5: Design FSMs, develop datapath and controller architectures, model memory, and apply pipelining for efficient processor design.

Course Contents

Module 1: Introduction

Overview of Digital Design with Verilog HDL, emergence of HDLs, typical HDL-based design flow, Verilog HDL, trends in HDLs, simulation vs. modelling.

Module 2: Advanced Design using Verilog

Introduction to HDL and typical HDL flow – Verilog HDL, top-down and bottom-up methodology, modules and module instances, Verilog constructs, Verilog timing regions, blocking and non-blocking statements, gate-level modelling, synthesizable constructs and design methodology for synthesis, timing analysis with constraints, inferring combinational and sequential logic, delay statements, test bench.

Module 3: Design using SystemVerilog

Fundamentals of SystemVerilog for verification of RTL, fundamentals of constraint random verification methodology, fundamentals of layered testbench architecture, creating generator, driver, monitor, scoreboard, understanding class, processes, interfaces and constraints, environment classes, inheritance, polymorphism, randomization in SystemVerilog, interface and mod port, transaction level verification (BFM – Bus Functional Model), usage of local variables in concurrent assertions, assertion, application of immediate assertions to digital systems, application of concurrent assertions to digital systems, application of assertions in FSM, usage of assertions in SystemVerilog TB.

Module 4: Fundamentals of Universal Verification Methodology

Universal Verification Methodology (UVM), verification process, basic test bench functionality, directed testing, methodology basics, constrained-random stimulus, functional coverage, test bench components, layered test bench, building layered test bench, simulation environment phases, maximum code reuse, test bench performance, reporting macros and associated actions, UVM object and UVM component, UVM phases, TLM communication, sequences, UVM debugging features, building UVM verification environment from scratch, verification of combinational circuits, verification of sequential circuits.

Module 5: FSM & Processor Design

FSM modelling, data path and controller design, modelling memory, pipelining, and design of a processor.

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	-	-	-	1	1	-	2
CO2	3	3	3	3	3	-	-	-	1	2	-	3
CO3	3	3	3	3	3	1	-	-	2	2	1	3
CO4	3	3	3	3	3	-	-	-	2	2	-	3
CO5	3	3	3	3	3	1	-	-	2	2	1	3

Note: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not matched.

Course Name: Deep Learning

Course code: MECE203A
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

Course Outcomes

At the end of this course, masters will be able to:

CO1: Identify and analyze suitable deep learning algorithms for various domains and real-world problems.

CO2: Explain the mathematical foundations and fundamental concepts underlying deep learning models.

CO3: Design and implement deep supervised learning architectures for text and image data.

CO4: Apply deep learning techniques to develop efficient solutions for practical applications in vision, NLP, and other fields.

CO5: Evaluate and compare performance of different deep learning models using modern tools and frameworks.

Course Content

Module 1:

Introduction: General measurement and diagnostic system, classification of signals, introduction to biomedical signals, Biomedical signal acquisition and processing, Difficulties in signal acquisition. ECG: ECG signal origin, ECG parameters-QRS detection different techniques, ST segment analysis, Arrhythmia, Arrhythmia analysis, Arrhythmia monitoring system.

Module 2:

ECG Data Reduction: Direct data compression Techniques: Turning Point, AZTEC, Cortes, FAN, Transformation Compression Techniques: Karhunen-Loeve Transform, Other data compression Techniques: DPCM, Huffman coding, Data compression Technique's comparison. Signal Averaging: Basics of signal averaging, Signal averaging as a digital filter, A typical Average, Software and limitations of signal averaging.

Module 3:

Frequency Domain Analysis: Introduction, Spectral analysis, linear filtering, cepstral analysis and homomorphic filtering. Removal of high frequency noise (power line interference), motion artifacts (low frequency) and power line interference in ECG. Time Series Analysis: Introduction, AR models, Estimation of AR parameters by method of least squares and Durbin's algorithm, ARMA models. Spectral modelling and analysis of PCG signals.

Module 4:

Spectral Estimation: Introduction, Blackman-Tukey method, The periodogram, Pisarenko's Harmonic decomposition, Prony's method, Evaluation of prosthetic heart valves using PSD techniques. Comparison of the PSD estimation methods.

Module 5:

Event Detection and waveform analysis: Need for event detection, Detection of events & waves, Correlation analysis of EEG signals, The matched filter, Detection of the P wave, Identification of heart sounds, Morphological analysis of ECG waves, analysis of activity.

Module 6:

Adaptive Filtering: Introduction, General structure of adaptive filters, LMS adaptive filter, adaptive noise cancellation, Cancellation of 60 Hz interference in ECG, cancellation of ECG from EMG signal, Cancellation of maternal ECG in fetal ECG. EEG: EEG signal characteristics, Sleep EEG classification and epilepsy.

References

1. Samir Palnitkar, *Verilog HDL, A Guide to Digital Design and Synthesis*, Second Edition, Pearson Education, 2004.
2. J. Bhaskar, *Verilog HDL Synthesis*, BS Publications, 2001.
3. Blaine Readler, *Verilog by Example: A Concise Introduction for FPGA Design*, ARC Press.
4. Chris Spear, Greg Tumbush, *SystemVerilog for Verification: A Guide to Learning the Testbench Language Features*, 3rd Edition, Springer.
5. Basavaraj Hakari, *SystemVerilog for Verification: SystemVerilog for RTL Verification*, Notion Press.
6. Vanessa R. Cooper, *Getting Started with UVM: A Beginner's Guide*, Verilab Publishing.
7. Sung-Mo Kang, Yusuf Leblebici, *CMOS Digital Integrated Circuits: Analysis & Design*, McGraw-Hill Higher Education.
8. Pran Kurup, Taher Abbasi, *Logic Synthesis Using Synopsys*, Springer-Verlag.
9. Soha Hassoun, Tsutomu Sasao, *Logic Synthesis and Verification: 654*, Springer-Verlag.

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	-	-	-	1	1	-	2
CO2	3	3	2	2	2	-	-	-	1	1	-	2
CO3	3	3	3	3	3	-	-	-	2	2	-	3
CO4	3	3	3	3	3	1	-	-	2	2	1	3
CO5	3	2	3	3	3	-	-	-	2	2	-	3

Note: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not matched.

Course Name: IoT

Course code: MECE203B
Contact: 3:0:0
Total Lecture Hours: 35
Credit: 3
Prerequisite: Concept of networking, microprocessor and microcontroller, programming language.

Course Outcomes

After studying this course, masters will be able to:

CO1: Interpret the impact and challenges posed by IoT networks leading to new architectural models.

CO2: Compare the deployment of smart objects and the technologies to connect them to networks.

CO3: Appraise the role of IoT protocols for efficient network communication.

CO4: Interpret the need for Data Analytics and Security in IoT.

CO5: Illustrate different sensor technologies for sensing real-world entities and identify IoT applications in industry.

Course Contents

Module 1:

What is IoT, Genesis of IoT, IoT and Digitization, IoT Impact, Convergence of IT and IoT, IoT Challenges, IoT Network Architecture and Design, Drivers Behind New Network Architectures, Comparing IoT Architectures, A Simplified IoT Architecture, The Core IoT Functional Stack, IoT Data Management and Compute Stack (concept of Fog, Edge and Cloud).

Module 2:

Smart Objects: The "Things" in IoT, Sensors, Actuators, and Smart Objects, Sensor Networks, Connecting Smart Objects, Communications Criteria, IoT Access Technologies.

Module 3:

IP as the IoT Network Layer, The Business Case for IP, The need for Optimization, Optimizing IP for IoT, Profiles and Compliances, Application Protocols for IoT, The Transport Layer, IoT Application Transport Methods.

Module 4:

Data and Analytics for IoT, An Introduction to Data Analytics for IoT, Machine Learning, Big Data Analytics Tools and Technology, Edge Streaming Analytics, Network Analytics, Securing IoT, A Brief History of OT Security, Common Challenges in OT Security, How IT and OT Security Practices and Systems Vary, Formal Risk Analysis Structures: OCTAVE and FAIR, The Phased Application of Security in an Operational Environment.

Module 5:

IoT Physical Devices and Endpoints - Arduino UNO: Introduction to Arduino, Arduino UNO, Installing the Software, Fundamentals of Arduino Programming. IoT Physical Devices and Endpoints - Raspberry Pi: Introduction to Raspberry Pi, About the Raspberry Pi Board: Hardware Layout, Operating Systems on Raspberry Pi, Configuring Raspberry Pi, Programming Raspberry Pi with Python, Connecting Raspberry Pi via SSH, Smart City IoT Architecture.

Note: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not mapped.

Text Books

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, *IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things*, 1st Edition, Pearson Education (Cisco Press Indian Reprint).
2. Srinivasa K G, *Internet of Things*, Cengage Learning India, 2017.

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	1	-	-	-	1	1	-	2
CO2	3	3	2	2	2	-	-	-	1	1	-	2
CO3	3	3	3	3	2	-	-	-	2	2	-	3
CO4	3	2	3	3	3	1	-	-	2	2	1	3
CO5	3	2	3	3	3	-	-	-	2	2	-	3

Course Name: Wireless & Mobile Communication

Course code: MECE203C
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

Course Outcomes

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

CO1: Design appropriate mobile communication systems.

CO2: Apply frequency-reuse concept in mobile communications, and analyze its effects on interference, system capacity, and handoff techniques.

CO3: Distinguish various multiple-access techniques for mobile communications (FDMA, TDMA, CDMA), and evaluate their advantages and disadvantages.

CO4: Analyze path loss and interference for wireless telephony and assess their influence on mobile communication system performance.

CO5: Describe upcoming technologies like 4G, 5G, etc.

Course contents

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, GSM subsystems, GSM Logical Channels, Data Encryption in GSM, Mobility Management, Call Flows in GSM. 2.5G Standards: High speed Circuit Switched Data (HSCSD), General Packet Radio Service (GPRS). 2.75G Standards: EDGE.

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).

Module 3

Mobile Radio Propagation: Large Scale Path Loss, Free Space Propagation Model, Reflection, Ground Reflection (Two-Ray) Model, Diffraction, Scattering, Practical Link Budget Design using Path Loss Models, Outdoor Propagation Models, Indoor Propagation Models, Signal Penetration into Buildings. Small Scale Fading and Multipath Propagation, Impulse Response Model, Multipath Measurements, Parameters of Multipath channels, Types of Small Scale Fading: Time Delay Spread; Flat, Frequency selective, Doppler Spread; Fast and Slow fading.

Module 4

Equalization, Diversity: Equalizers in a communications receiver, Algorithms for adaptive equalization, diversity techniques – space, polarization, frequency diversity, Interleaving.

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 CDMA Call Processing, Soft Handoff, Evolution of IS-95 (CDMA One) to CDMA 2000, CDMA 2000 layering structure and channels.

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.

References

1. V.K. Garg, J.E. Wilkes, *Principle and Application of GSM*, Pearson Education, 5th edition, 2008.
2. T.S. Rappaport, *Wireless Communications Principles and Practice*, 2nd edition, PHI, 2002.
3. William C.Y. Lee, *Mobile Cellular Telecommunications: Analog and Digital Systems*, 2nd edition, TMH, 1995.
4. Asha Mehrotra, *A GSM System Engineering*, Artech House Publishers, Boston, London, 1997.

CO-PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	3	2	3	1	1	1	2	2	1
CO2	2	3	3	2	3	1	1	1	1	2	1
CO3	2	3	2	3	3	1	1	1	1	3	1
CO4	3	3	2	3	3	1	1	1	2	2	1
CO5	2	2	2	2	3	1	1	1	2	2	2

Course Name: Advanced Semiconductor Devices

Course code: MECE203D
Contact: 3:0:0
Total contact Hours: 36
Credit: 3

Course Outcomes

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

CO1: Explain the concepts of metal–semiconductor contacts, MOS capacitors and operation of MOSFET.

CO2: Describe the significance of heterojunction semiconductors such as HBT & HEMT.

CO3: Illustrate the operation of photonic devices such as LED, Laser, photodiode, phototransistor and solar cell.

CO4: Explain the behaviour of microwave devices such as Gunn Diode, Tunnel Diode, IMPATT Diode.

CO5: Depict the characteristics of Memristor, Carbon nanotube/nanowire, Graphene, and Single Electron Transistor.

Course Contents

Module 1: Fundamentals of MOSFET Device

Introduction, Ohmic contact, Rectifying contact, Current transport across a metal–semiconductor boundary, Fermi-level, MOSFET Operation Principles, MOS capacitances, Band Bending in the MOS Capacitor, Solution of Poisson's Equation for the MOS Capacitor, C–V characteristics at low and high frequencies.

Module 2: Physics of Advanced MOSFET Structures

Drift–Diffusion Approach for IV, Gradual Channel Approximation, Short geometry effects, Sub-threshold current and slope, Body effect, Leakage mechanisms in thin gate oxide, High-K–Metal Gate MOSFET devices and technology issues, Silicon on Insulator (SOI).

Module 3: Compound Semiconductor Devices

Compound semiconductors, Heterojunction bipolar transistors (HBT), High electron mobility transistors (HEMT).

Module 4: Photonic Devices

Light-emitting diodes (LEDs), Laser diodes, Photodetectors and phototransistors, Solar cells.

Module 5: Microwave Devices

Operation, IV characteristics and applications of Gunn Diode, Tunnel Diode, IMPATT Diode.

Module 6: State-of-the-art Semiconductor Devices

Emerging non-volatile memory materials and devices (Memristor), Carbon nanotube/nanowire, Graphene, Single Electron Transistor.

References

1. S. M. Sze and Kwok K. Ng, *Physics of Semiconductor Devices (3rd ed.)*, Wiley, 2007.
2. Michael Shur, *Physics of Semiconductor Devices*, Prentice Hall.
3. Mark Lundstrom & Jing Guo, *Nanoscale Transistors: Device Physics, Modeling & Simulation*, Springer, 2005.
4. Ben G. Streetman and Sanjay Banerjee, *Solid State Electronic Devices*, Pearson.
5. Yannis Tsividis, *Operation and Modeling of the MOS Transistor*, 2nd Ed., Oxford University Press.
6. Yuan Taur and Tak H. Ning, *Fundamentals of Modern VLSI Devices*, 2nd Ed., Cambridge University Press, 2009.
7. S. M. Sze and K. N. Kwok, *Physics of Semiconductor Devices*, 3rd Ed., John Wiley & Sons, 2006.

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	-	-	-	-	1	-	2
CO2	3	3	3	2	3	-	-	-	-	1	-	2
CO3	3	3	3	2	2	-	-	-	1	1	-	2
CO4	3	3	3	2	2	-	-	-	-	1	-	2
CO5	3	3	3	2	3	-	-	-	-	1	-	3

Note: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not matched.

Course Name: MIMO System

Course code: MECE204A
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

Course Outcomes

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

CO1: Understand channel modelling, propagation, MIMO capacity, space-time coding, and MIMO receivers.

CO2: Analyze MIMO for multi-carrier systems (e.g., MIMO-OFDM), multi-user communications, and multi-user MIMO.

CO3: Explain cooperative and coordinated multi-cell MIMO, and describe MIMO in 4G standards (LTE, LTE-Advanced, WiMAX).

CO4: Perform mathematical modelling and analysis of MIMO systems.

CO5: Apply beamforming, channel estimation, and advanced MIMO techniques in modern wireless communication.

Course Content

Module 1:

Introduction to Multi-antenna Systems, Motivation, Types of multi-antenna systems, MIMO vs. multi-antenna systems.

Module 2:

Diversity, Exploiting multipath diversity, Transmit diversity, Space-time codes, The Alamouti scheme, Delay diversity, Cyclic delay diversity, Space-frequency codes, Receive diversity, The rake receiver, Combining techniques, Spatial Multiplexing, Spectral efficiency and capacity, Transmitting independent streams in parallel, Mathematical notation.

Module 3:

The generic MIMO problem, Singular Value Decomposition, Eigenvalues and eigenvectors, Equalising MIMO systems, Disadvantages of equalising MIMO systems, Pre-distortion in MIMO systems, Disadvantages of pre-distortion in MIMO systems, Pre-coding and combining in MIMO systems, Advantages and disadvantages, Channel state information.

Module 4:

Codebooks for MIMO, Beamforming, Beamforming principles, Increased spectrum efficiency, Interference cancellation, Switched beamformer, Adaptive beamformer, Narrowband and Wideband beamformer.

Module 5:

Case study: MIMO in LTE, Codewords to layers mapping, Pre-coding for spatial multiplexing, Pre-coding for transmit diversity, Beamforming in LTE, Cyclic delay diversity based pre-coding, Pre-coding codebooks, Propagation Channels, Time & frequency channel dispersion, AWGN and multipath propagation channels, Delay spread values and time variations, Fast and slow fading environments, Complex baseband multipath channels, Narrowband and wideband channels, MIMO channel models.

Module 6:

Channel Estimation, Channel estimation techniques, Estimation and tracking, Training based channel estimation, Blind channel estimation, Channel estimation architectures, Iterative channel estimation, MMSE channel estimation, Correlative channel sounding, Channel estimation in single carrier systems, Channel estimation for CDMA, Channel estimation for OFDM.

References

- Claude Oestges, Bruno Clerckx, *MIMO Wireless Communications: From Real-world Propagation to Space-time Code Design*, Academic Press, 1st edition, 2010.
- Mohinder Janakiraman, *Space - Time Codes and MIMO Systems*, Artech House Publishers, 2004.

CO-PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	3	2	3	1	1	1	1	2	1
CO2	2	3	3	3	3	1	1	1	1	2	1
CO3	2	2	3	2	3	1	1	1	1	3	1
CO4	3	3	3	3	3	1	1	1	2	2	1
CO5	2	2	2	3	3	1	1	1	2	2	2

Note: 3 = Strong, 2 = Medium, 1 = Low, blank = No mapping.

Course Name: MEMS

Course code: MECE204B
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

Course Outcomes

At the end of this course, masters will be able to:

CO1: Understand history and market of MEMS, silicon properties, and microtechnology basics.

CO2: Understand electromechanical transduction techniques.

CO3: Understand characteristics and fundamental building blocks of MEMS systems.

CO4: Understand fabrication technology of MEMS systems.

CO5: Investigate application-specific MEMS systems.

Course Contents

Module I: Introduction

History of MEMS technology, market for MEMS, properties of silicon, basics of microtechnology, commercial MEMS devices, application of MEMS devices.

Module II: Electromechanical Transduction Techniques

Electrostatic transduction, electromagnetic transduction, piezoelectric transduction, piezoresistive transduction.

Module III: Characteristics of MEMS Devices

Static characteristics, linearity, nonlinearity, sensitivity, resolution, hysteresis, dynamic characteristics, response time, delay time, gain, bandwidth, quasi-static characteristics of MEMS devices.

Module IV: MEMS Device Fabrication Processes

MEMS materials, bulk micromachining, silicon anisotropic etching, surface micromachining.

Module V: Scaling Effect and Reliability of MEMS Devices

Effect of inertia in MEMS devices, scaling effect of MEMS devices, concept of reliability, mathematical modelling of reliability, reliability analysis of MEMS devices.

Module VI: Case Studies in MEMS

Application-specific MEMS devices, MEMS blood pressure sensors, MEMS microphone, MEMS accelerometer, MEMS gyro.

References

1. S. D. Senturia, *Microsystem Design*, Springer, 1st Edition, 2004.
2. K. J. Vinoy, S. Gopalakrishnan, K. N. Bhat, V. K. Aatre, G. K. Ananthasuresh, *Micro and Smart Systems*, Wiley India Pvt. Ltd., 2010.
3. Chang Liu, *Foundations of MEMS*, 2nd Edition, 2011.

4. Marc Madou, *Fundamentals of Microfabrication and Nanotechnology*, 3rd Edition.
5. Stephen D. Senturia, *Microsystem Design*.
6. Gregory T. A. Kovacs, *Micromachined Transducers Sourcebook*.

CO-PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	3	2	3	1	1	1	1	2	1
CO2	2	3	3	3	3	1	1	1	1	2	1
CO3	2	2	3	2	3	1	1	1	1	3	1
CO4	3	3	3	3	3	1	1	1	2	2	1
CO5	2	2	2	3	3	1	1	1	2	2	2

Note: 3 = Strong, 2 = Medium, 1 = Low, blank = No mapping.

Course Name: VLSI Design Verification & Testing

Course code: MECE204C
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

Course Name: Antennas and Radiating Systems

Course code: MECE204D
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

Course Outcomes

At the end of this course, masters will be able to:

CO1: Compute the far field distance, radiation pattern and gain of an antenna for given current distribution.

CO2: Estimate the input impedance, efficiency and ease of match for antennas.

CO3: Analyze linear wire, loop antennas, and antenna arrays, and compute the array factor for various configurations.

CO4: Design and evaluate antennas and antenna arrays for desired radiation pattern characteristics.

CO5: Apply modern antenna technologies such as microstrip, reflector, and MIMO systems for real-world applications.

Course Contents

Module 1: Types and Fundamental Parameters of Antennas

Wire antennas, Aperture antennas, Microstrip antennas, Array antennas, Reflector antennas, Lens antennas, Radiation Mechanism, Current distribution on thin wire antenna. 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.

Module 2: Linear Wire and Loop 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.

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.

Module 4: Aperture and Horn Antennas

Huygen's Field Equivalence principle, radiation equations, Rectangular Aperture, Circular Aperture. Horn Antennas: E-Plane, H-plane Sectoral horns, Pyramidal and Conical horns.

Module 5: Microstrip Antennas

Basic Characteristics, Feeding mechanisms, Method of analysis, Rectangular Patch, Circular Patch.

Module 6: Reflector Antennas and MIMO

Plane reflector, Parabolic reflector, Cassegrain reflectors, Introduction to MIMO.

References

1. Constantine A. Balanis, *Antenna Theory Analysis and Design*, John Wiley & Sons, 4th edition, 2016.
2. John D. Kraus, Ronald J. Marhefka, Ahmad S. Khan, *Antennas for All Applications*, Tata McGraw-Hill, 2002.
3. R.C. Johnson and H. Jasik, *Antenna Engineering Handbook*, McGraw-Hill, 1984.
4. I.J. Bhal and P. Bhartia, *Microstrip Antennas*, Artech House, 1980.

CO-PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1				2		2
CO2	2	3	3	2	2	1				2		2
CO3	3	3	3	3	2		1			2	1	2
CO4	2	2	3	3	3		1			2	1	2
CO5	2	3	3	2	3	1				2	1	3

Note: 3 = Strong, 2 = Medium, 1 = Low, blank = No mapping.

Course Name: Pedagogy Studies

Course code: MECE205
Contact: 2:0:0
Total Contact Hours: 24
Credit: 2

Course Outcomes

At the end of this course, masters will be able to:

CO1: Understand what pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.

CO2: Analyze evidence on the effectiveness of these pedagogical practices, considering conditions and populations of learners.

CO3: Evaluate how teacher education (curriculum and practicum) and the school curriculum with guidance materials can best support effective pedagogy.

CO4: Review existing evidence on pedagogy to inform programme design and policy making undertaken by agencies and researchers.

CO5: Identify critical evidence gaps to guide future research and development.

Course Contents

Module 1: Introduction and Methodology

Aims and rationale, Policy background, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education, Conceptual framework, Research questions, Overview of methodology and searching.

Module 2: Thematic Overview

Pedagogical practices used by teachers in formal and informal classrooms in developing countries, Curriculum, Teacher education.

Module 3: Evidence on Effectiveness

Evidence on the effectiveness of pedagogical practices. Methodology for the in-depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches. Teachers' attitudes and beliefs and Pedagogic strategies.

Module 4: Professional Development

Alignment with classroom practices and follow-up support, Peer support, Support from the head teacher and the community. Curriculum and assessment, Barriers to learning, limited resources and large class sizes.

Module 5: Research Gaps and Future Directions

Research design, Contexts, Pedagogy, Teacher education, Curriculum, and assessment, Dissemination and research impact.

References

1. Ackers J, Hardman F (2001). Classroom interaction in Kenyan primary schools, *Compare*, 31(2): 245-261.

2. Agrawal M (2004). Curricular reform in schools: The importance of evaluation, *Journal of Curriculum Studies*, 36(3): 361-379.

3. Akyeampong K (2003). Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.

4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013). Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? *International Journal of Educational Development*, 33(3): 272–282.

5. Alexander RJ (2001). *Culture and pedagogy: International comparisons in primary education.* Oxford and Boston: Blackwell.

CO-PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	1	2	1	1	2	1	2
CO2	2	3	2	2	2	1	2	1	2	3	2	2
CO3	2	3	3	2	2	2	2	1	2	3	2	3
CO4	1	2	2	3	2	2	1	1	2	3	2	3
CO5	1	2	2	2	2	2	1	1	1	2	2	3

Note: 3 = Strong, 2 = Medium, 1 = Low, blank = No mapping.

Course Name: Cryptography & Coding Lab

Course Code: MECE291
Contact: 0:0:4
Credit: 2

Course Outcomes

At the end of this course, masters will be able to:

CO1: Implement classical cryptographic algorithms such as substitution and transposition ciphers.

CO2: Analyze the security level and limitations of classical ciphers.

CO3: Apply modular arithmetic and matrix operations in cryptographic algorithms.

CO4: Develop encryption and decryption algorithms for secure communication.

CO5: Evaluate the effectiveness of cryptographic techniques through experimentation and simulation.

Laboratory Experiments

1. Caesar Cipher
2. Monoalphabetic Substitution Cipher
3. Affine Cipher
4. Polyalphabetic Substitution Cipher – Vigenere Cipher
5. Playfair Cipher
6. Hill Cipher
7. Columnar Transposition Cipher
8. Rail Fence Cipher
9. DES
10. AES

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	-	-	-	1	1	-	2
CO2	3	3	2	3	2	-	-	-	1	1	-	2
CO3	3	3	3	3	3	-	-	-	1	1	-	2
CO4	3	3	3	3	3	1	-	-	2	2	1	3
CO5	3	3	3	3	3	1	1	1	2	2	1	3

Note: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not matched.

Course Name: Deep Learning Lab

Course Code: MECE293A
Contact: 4:0:0
Total Contact Hours: 40
Credit: 3

Course Outcomes

At the end of this course, masters will be able to:

CO1: Identify suitable deep learning algorithms for different types of learning tasks and real-world applications across various domains.

CO2: Explain the mathematical foundations of deep learning models and describe their architectures.

CO3: Design and implement deep supervised learning architectures for text, image, and sequence data.

CO4: Apply advanced deep learning models (e.g., CNNs, RNNs, Transformers, GNNs) for solving complex problems.

CO5: Evaluate and compare the performance of deep learning models to design efficient algorithms for real-world applications.

Laboratory Experiments

1. Conceptual and mathematical foundation and computational investigations of recent deep models with Python/Matlab.
2. Newer convolutional neural networks such as VGG Net, ResNet; sequence models including attention-based models such as Transformers with Python/Matlab.
3. Graph representation learning using graph neural networks with Python/Matlab.
4. Implement maximum likelihood algorithm.
5. Implement Bayes classifier.
6. Implement linear regression.
7. Design a classifier using perceptron rule.
8. Design a classifier using feedforward back-propagation and delta rule algorithms.
9. Implement deep learning algorithm.
10. Implement linear discriminant algorithm.
11. Design a two-class classifier using SVM.
12. Design a multiclass classifier using SVM.
13. Perform unsupervised learning.

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	-	-	-	1	1	-	2
CO2	3	3	2	3	2	-	-	-	1	1	-	2
CO3	3	3	3	3	3	-	-	-	2	2	-	3
CO4	3	3	3	3	3	1	-	-	2	2	1	3
CO5	3	3	3	3	3	1	1	1	2	2	1	3

Note: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not mapped.

References

1. Goodfellow, I., Bengio, Y., and Courville, A., *Deep Learning*, MIT Press, 2016.
2. Bishop, C. M., *Pattern Recognition and Machine Learning*, Springer, 2006.
3. Yegnanarayana, B., *Artificial Neural Networks*, PHI Learning Pvt. Ltd, 2009.
4. Golub, G. H., and Van Loan, C. F., *Matrix Computations*, JHU Press, 2013.
5. Satish Kumar, *Neural Networks: A Classroom Approach*, Tata McGraw-Hill Education, 2004.

Course Name: IOT Lab

Course Code: MECE293B
Contact: 0:0:4
Total Contact Hours: 40
Credit: 2

Course Outcomes

After studying this course, masters will be able to:

CO1: Apply sensors to read data.

CO2: Design I/O based system using LED and push button.

CO3: Develop LCD based output.

CO4: Analyze data from remotely placed camera.

CO5: Design cloud-based automation system.

Laboratory Experiments

Following experiments can be done using Arduino/Raspberry Pi:

1. Wireless Temperature Monitoring System
2. Remote access to Raspberry Pi
3. LED Blink and Pattern
4. 7 Segment Display
5. Push Button
6. LED Pattern with Push Button Control
7. Push Button Counter
8. LCD 16x2 Display
9. Servo Motor Control with Arduino
10. Interfacing camera
11. IoT Data Logging using Beaglebone Black and Thingspeak

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	-	-	-	1	1	-	2
CO2	3	3	3	3	2	-	-	-	2	1	-	2
CO3	3	3	3	3	3	-	-	-	2	1	-	2
CO4	3	3	3	3	3	1	-	-	2	2	1	3
CO5	3	3	3	3	3	1	1	1	2	2	1	3

Note: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not mapped.

Course Name: Wireless & Mobile Communication Lab

Course Code: MECE293C
Contact: 0:0:4
Credit: 2

Course Outcomes

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

CO1: Identify cellular concepts, GSM and CDMA networks.

CO2: Design GSM handset experiments using fault insertion techniques.

CO3: Explain 3G communication systems through AT commands and DSSS-based CDMA concepts.

CO4: Analyze performance of DSSS, PN codes, spreading factor, and processing gain in CDMA.

CO5: Develop concepts of Software Defined Radio (SDR) in real-time environments.

List of Experiments

1. Understanding cellular fundamentals like frequency reuse, interference, cell splitting, multipath environment, coverage and capacity issues using communication software.
2. Studying GSM and CDMA architecture, network concepts, call management, call setup, call release, security, power control, handoff process and types, rake receiver, etc.
3. Study of GSM handset for various signaling and fault insertion techniques (Major GSM handset sections: clock, SIM card, charging, LCD module, keyboard, user interface).
4. To study transmitters and receiver sections in mobile handset and measure frequency band signal and GMSK modulating signal.
5. To study various GSM AT Commands, their use, and developing new applications using them. Understanding 3G communication system with features like transmission of voice and video calls, SMS, MMS, TCP/IP, HTTP, GPS, and file system by AT commands in 3G network.
6. Study of DSSS technique for CDMA; observe effects of variation of PN codes, chip rate, spreading factor, and processing gain on performance.
7. Learning and developing concepts of Software Radio in real time environment by studying the building blocks like baseband and RF section, convolution encoder, interleaver and de-interleaver.
8. To study and analyze different modulation techniques in time and frequency domain using SDR kit.

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	-	-	-	1	1	-	2
CO2	3	3	3	3	3	-	-	-	2	2	-	2
CO3	3	3	3	3	3	1	-	-	2	2	-	3
CO4	3	3	3	3	3	2	1	-	2	2	1	3
CO5	3	3	3	3	3	2	2	1	2	2	1	3

Note: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not mapped.

Course Name: Advanced Semiconductor Devices Lab

Course Code: MECE293D
Contact: 0:0:4
Credit: 2

Course Outcomes

At the end of this course, masters will be able to:

CO1: Analyze the I-V and C-V characteristics of MOSFET devices.

CO2: Evaluate the current–voltage behavior of special diodes such as Tunnel, Gunn, and IMPATT.

CO3: Examine the performance of optoelectronic devices such as solar cells through I-V characterization.

CO4: Investigate the electrical characteristics of Heterojunction Bipolar Transistors (HBTs).

CO5: Interpret and compare the experimental results of different semiconductor devices for practical applications.

List of Experiments

1. I-V characteristics of MOSFET.
2. C-V characteristics of MOSFET.
3. I-V characteristics of Tunnel Diode.
4. I-V characteristics of Gunn Diode.
5. I-V characteristics of IMPATT Diode.
6. I-V characteristics of Solar Cell.
7. I-V characteristics of HBT.

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	-	-	-	1	1	-	2
CO2	3	3	2	2	2	-	-	-	1	1	-	2
CO3	3	3	3	2	2	1	-	-	1	2	-	2
CO4	3	3	3	3	3	2	1	-	2	2	-	3
CO5	3	3	3	3	3	2	2	1	2	2	1	3

Note: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not mapped.

Course Name: High Performance Networks

Course Code: MECE301A
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

Course Outcomes

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

CO1: Apply knowledge of mathematics, probability, and statistics to model and analyze networking protocols.

CO2: Design, implement, and analyze computer networks.

CO3: Identify, formulate, and solve network engineering problems.

CO4: Demonstrate knowledge of contemporary issues in high-performance computer networks.

CO5: Use techniques, skills, and modern networking tools necessary for engineering practice.

Course Content

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.

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.

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.

Module 4:

Traffic Modeling: Little's theorem, Need for modeling, Poisson modeling, Non-Poisson models, Network performance evaluation.

Module 5:

Network Security and Management: Principles of cryptography, Authentication, integrity, key distribution and certification, Access control and firewalls, attacks and countermeasures, security in many layers.

Module 6:

Infrastructure for network management, The Internet standard management framework—SMI, MIB, SNMP, Security and administration, ASN.1.

References

1. Kershenbaum A., *Telecommunications Network Design Algorithms*, Tata McGraw Hill, 1993.
2. Larry Peterson & Bruce David, *Computer Networks: A System Approach*, Morgan Kaufmann, 2003.
3. Douskalis B., *IP Telephony: The Integration of Robust VoIP Services*, Pearson Education Asia, 2000.
4. Warland J., Varaiya P., *High-Performance Communication Networks*, Morgan Kaufmann, 1996.
5. Stallings W., *High-Speed Networks: TCP/IP and ATM Design Principles*, Prentice Hall, 1998.
6. Leon Garcia, Widjaja, *Communication Networks*, Tata McGraw Hill, 2002 (7th reprint).
7. Stallings W., *Network Security Essentials*, Pearson Education Asia, 4th Edition, 2011.

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	2	-	-	-	-	1	-	3
CO2	3	3	3	3	3	-	-	-	2	2	-	3
CO3	3	3	3	3	3	-	-	-	2	2	-	3
CO4	2	2	2	2	2	2	1	1	1	3	2	3
CO5	3	3	3	3	3	2	-	-	2	3	2	3

Note: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not mapped.

Course Name: Optimization Techniques

Course Code: MECE301B
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

Course Outcomes

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

CO1: Formulate engineering minima/maxima problems into the framework of optimization.

CO2: Apply efficient computational procedures to solve optimization problems.

CO3: Implement important optimization methods using MATLAB.

CO4: Analyze linear, nonlinear, constrained, and unconstrained optimization models.

CO5: Evaluate and compare optimization algorithms for real-world engineering applications.

Course Content

Unit 1: Mathematical Preliminaries

- Linear algebra and matrices
- Vector space, eigen analysis
- Elements of probability theory
- Elementary multivariable calculus

Unit 2: Linear Programming

- Introduction to linear programming model
- Simplex method, Duality
- Karmarkar's method

Unit 3: Unconstrained Optimization

- One-dimensional search methods
- Gradient-based methods
- Conjugate direction and quasi-Newton methods

Unit 4: Constrained Optimization

- Lagrange theorem
- FONC, SONC, and SOSC conditions

Unit 5: Non-linear Problems

- Non-linear constrained optimization models
- KKT conditions
- Projection methods

References

1. Edwin P.K. Chong, Stanislaw H. Zak, *An Introduction to Optimization*.
2. Dimitri P. Bertsekas, *Nonlinear Programming*.

CO–PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	-	-	-	-	1	-	2
CO2	3	3	3	3	2	-	-	-	-	1	-	3
CO3	2	2	3	3	3	-	-	-	-	2	-	2
CO4	3	3	3	3	2	-	-	-	-	2	-	3
CO5	2	3	3	3	3	-	-	-	2	3	-	3

Note: 3 = Strong, 2 = Moderate, 1 = Weak, - = Not mapped.

Course Name: Geographical Information System

Course code: MECE301C
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

Course Outcomes

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

CO1: Illustrate the fundamentals, scope, and applications of GIS.

CO2: Explain remote sensing techniques and data acquisition processes used in GIS.

CO3: Demonstrate the basic concepts and applications of GPS and satellite-based positioning systems.

CO4: Apply spatial analysis, integration, and modelling techniques using GIS tools.

CO5: Develop skills in Web GIS, DEM, TIN creation, and GIS software for real-world applications.

Course Contents

Module 1:

Introduction, Definitions, Basic Concepts, history and evolution, Components, Need, Scope, interdisciplinary relations, applications areas, and overview of GIS. GIS data: spatial and non-spatial, spatial data model: raster, vector, Topology and topological models; Spatial referencing using coordinates and geographic identifiers, metadata; Spatial data acquisition; Attribute data sources; Spatial and attribute data input; Data storage, RDBMS, database operations; Spatial and non-spatial data editing functions; Quality of spatial data; GIS analysis functions: Retrieval, classification, measurement, neighbourhood, topographic, interpolation, overlay, buffering, spatial join and query, connectivity, network functions, watershed analysis, view-shed analysis, spatial pattern analysis, spatial autocorrelation, trend surface analysis; GIS presentation functions: data visualization methods, exporting data; Modern trends: Internet GIS, 3D GIS.

Module 2:

Concept of Remote Sensing, optical, thermal and microwave remote sensing, data acquisition, aircrafts and satellites, visual and digital remote sensing, analysis and interpretation of visual and digital remote sensing data, applications of remote sensing in geology, agriculture, forestry, urban and rural planning, land use / land cover, groundwater, mineral and hydrocarbon.

Module 3:

Basic concepts remote sensing satellite: GPS, GNSS, GLONAS.

Module 4:

Basic Spatial Analysis, Integration and Modelling: Logic operations, general arithmetic operations, general statistical operations, geometric operations, query and report generation from attribute data, geometric data search and retrieval, complex operations of attribute data, classification reclassification, integrated geometry and attributes, overlay, buffer zones, raster data overlay, integrated data analysis.

Module 5:

Web GIS: Definition, concept of Web GIS, History of web GIS, components of web GIS, internet, web GIS v/s Internet GIS, Applications of web GIS, users and stakeholders of web GIS, advantages and limitations of web GIS, Participatory GIS – Web-based GIS for Collaborative Planning and Public Participation.

Module 6:

Familiarization with GIS software, Geo-referencing & Projection, Spatial data entry, Spatial data editing & topology creation, Linking spatial & non-spatial data entry, Spatial & non-spatial query and analysis, Output map generation, Overlay Analysis, Buffer Creation and Analysis, Network Analysis & DEM and TIN Creation.

References

1. P.A. Vurrough, *Principles of GIS for Land Resources Assessment*, Oxford: Science Publications, 1986.
2. Goodchild, *GIS Principles*, Vol. 1.
3. Zhong-Ren Peng, Ming-Hsiang Tsou, *Internet GIS: Distributed Geographic Information Services for the Internet and Wireless Networks*, Wiley, 2003.
4. C.P. Lo, Albert K.W. Yeung, *Concepts and Techniques of Geographic Information Systems*, Prentice Hall of India, 2005.
5. Tor Bernhardsen, *Geographic Information Systems – An Introduction*, John Wiley & Sons, New York, 2002.
6. William Stalling, *Network Security Essentials*, Pearson Education Asia, 4th Edition, 2011.

CO-PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	2	1	1	1	1	2	2	3
CO2	2	3	2	3	3	1	1	1	1	2	2	3
CO3	2	2	2	3	3	1	1	1	1	2	2	3
CO4	3	3	2	3	3	2	1	1	2	2	3	3
CO5	2	2	2	3	3	2	1	2	2	3	3	3

Note: The scale is given as: 3 = Strong, 2 = Medium, 1 = Slight.

Course Name: Quantum Computing

Course code: MECE301D
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

Course Outcomes

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

CO1: Explain the fundamentals of quantum mechanics relevant to computing.

CO2: Illustrate the principles of quantum bits, quantum gates, and quantum circuits.

CO3: Apply quantum algorithms such as Deutsch, Grover's, and Shor's algorithm.

CO4: Analyze quantum error correction techniques and noise in quantum systems.

CO5: Demonstrate applications of quantum computing in cryptography, optimization, and communication.

Course Contents

Module 1: Introduction to Quantum Mechanics

Postulates of quantum mechanics, linear algebra for quantum computing, Dirac notation, quantum states, observables, measurement, tensor products.

Module 2: Quantum Bits and Quantum Gates

Qubits, Bloch sphere representation, single-qubit gates, multi-qubit gates, entanglement, Bell states, quantum circuits, measurement.

Module 3: Quantum Algorithms

Deutsch's algorithm, Bernstein-Vazirani algorithm, Simon's algorithm, Grover's search algorithm, Shor's factoring algorithm, Quantum Fourier Transform (QFT).

Module 4: Quantum Error Correction and Noise

Sources of quantum noise, decoherence, error models, quantum error correction codes (Shor code, Steane code), fault-tolerant quantum computation.

Module 5: Applications of Quantum Computing

Quantum cryptography, quantum key distribution (QKD), quantum teleportation, optimization problems, applications in machine learning, emerging trends and challenges.

References

1. Michael A. Nielsen and Isaac L. Chuang, *Quantum Computation and Quantum Information*, Cambridge University Press, 2010.
2. Phillip Kaye, Raymond Laflamme, and Michele Mosca, *An Introduction to Quantum Computing*, Oxford University Press, 2007.
3. Nouredine Zettili, *Quantum Mechanics: Concepts and Applications*, Wiley, 2009.

4. Eleanor G. Rieffel and Wolfgang H. Polak, *Quantum Computing: A Gentle Introduction*, MIT Press, 2011.

5. Noson S. Yanofsky and Mirco A. Mannucci, *Quantum Computing for Computer Scientists*, Cambridge University Press, 2008.

CO-PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	1	1	1	1	1	2	1	3
CO2	3	3	2	3	2	1	1	1	1	2	2	3
CO3	3	3	2	3	3	1	1	1	2	2	2	3
CO4	2	3	3	3	3	2	1	1	2	2	3	3
CO5	2	3	2	3	3	2	2	2	2	3	3	3

Note: The scale is given as: 3 = Strong, 2 = Medium, 1 = Slight.

Course Name: Business Analytics

Course Code: MCE302A
Lecture: 3 h/week
Credits: 3
Total Contact Hours: 48

Course Outcomes

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

CO1: Explain the concepts, scope, and processes of business analytics.

CO2: Apply statistical tools, regression, and forecasting methods to business problems.

CO3: Utilize predictive and prescriptive analytics models for decision making.

CO4: Manage business analytics projects including data quality, team management, and policy design.

CO5: Demonstrate applications of business analytics in real-world scenarios across diverse industries.

Course Contents

Module 1: Business Analytics and Statistical Tools

Overview and scope of business analytics, Business Analytics Process, relationship with organization, competitive advantages; Statistical notation, descriptive statistical methods, probability distribution and data modelling, sampling and estimation methods.

Module 2: Regression and Data Exploration

Modelling relationships and trends in data, simple linear regression, resources and personnel for business analytics, problem solving, data visualization, business analytics technology.

Module 3: Organizational Structures and Predictive Analytics

Team management, management issues, information policy design, outsourcing, ensuring data quality, measuring contribution, managing changes; Descriptive, predictive and prescriptive analytics, data mining methodologies, nonlinear optimization.

Module 4: Forecasting and Simulation

Qualitative and judgmental forecasting, statistical forecasting models, time series forecasting (stationary, trend, seasonality), regression forecasting, model selection; Monte Carlo simulation and risk analysis, product development, overbooking, and budgeting models.

Module 5: Decision Analysis

Formulating decision problems, strategies with/without outcome probabilities, decision trees, value of information, utility and decision making.

Unit 6: Recent Trends

Embedded and collaborative business intelligence, visual data recovery, data storytelling, and data journalism.

References

1. James Evans, *Business Analytics*, Pearson, 2nd Edition, 2017.
2. U. Dinesh Kumar, *Business Analytics: The Science of Data-Driven Decision Making*, Wiley, 2017.
3. Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, *Business Analytics: Principles, Concepts, and Applications*, Pearson, 2014.
4. Foster Provost and Tom Fawcett, *Data Science for Business*, O'Reilly Media, 2013.
5. Jay Liebowitz, *Business Analytics: An Introduction*, CRC Press, 2013.

CO-PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	1	1	1	1	1	2	1	2
CO2	3	3	2	3	2	1	1	1	1	2	2	3
CO3	3	3	3	3	3	1	1	1	2	2	2	3
CO4	2	3	3	3	3	2	1	1	2	2	3	3
CO5	2	3	2	3	3	2	2	2	2	3	3	3

Note: Scale – 3 = Strong, 2 = Medium, 1 = Slight.

Course Name: Industrial Safety

Course code: MECE302B
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

Course Outcomes

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

CO1: Analyze the causes of industrial accidents and apply appropriate control measures.

CO2: Understand the concepts and practices of maintenance engineering.

CO3: Analyze the effects of wear and corrosion and recommend suitable prevention techniques.

CO4: Apply systematic fault tracing methods for industrial equipment.

CO5: Implement periodic and preventive maintenance strategies for mechanical and electrical systems.

Course Content

Module 1:

Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, factories act 1948 salient points, safety color codes, fire prevention, firefighting equipment and methods.

Module 2:

Fundamentals of maintenance engineering: Definition, aim, functions, responsibilities, types of maintenance, tools used, maintenance cost, service life of equipment.

Module 3:

Wear and corrosion and their prevention: Types, causes, effects, wear reduction methods, lubricants and lubrication methods, corrosion types, principles, and prevention.

Module 4:

Fault tracing: Concept, importance, decision tree, applications in machine tools, pumps, compressors, IC engines, boilers, electrical motors.

Module 5:

Periodic and preventive maintenance: Inspection, overhauling, troubleshooting, preventive maintenance procedures for machine tools, pumps, compressors, DG sets, repair cycles.

References

1. Higgins & Morrow, *Maintenance Engineering Handbook*, Da Information Services.
2. H. P. Garg, *Maintenance Engineering*, S. Chand and Company.
3. Audels, *Pump-hydraulic Compressors*, McGraw Hill Publication.
4. Winterkorn, Hans, *Foundation Engineering Handbook*, Chapman & Hall, London.

CO-PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	3	3	2	1	2	2	2
CO2	2	3	2	2	2	1	1	1	2	1	2	3
CO3	3	2	3	2	2	2	2	1	1	2	2	2
CO4	2	2	3	3	2	1	1	2	2	2	1	2
CO5	2	3	3	2	3	2	1	2	2	2	2	3

Note: Scale – 3 = Strong, 2 = Medium, 1 = Slight.

Course Name: Operations Research

Course code: MECE302C
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

Course Outcomes

At the end of this course, masters will be able to:

CO1: Apply dynamic programming to solve problems of discrete and continuous variables.

CO2: Apply the concept of non-linear programming.

CO3: Carry out sensitivity analysis for optimization problems.

CO4: Model and solve real-world problems using optimization techniques.

CO5: Simulate optimization models for decision making in engineering and management.

Course Content

Module 1:

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

Module 2:

Formulation of a LPP, Graphical solution, revised simplex method, duality theory, dual simplex method, sensitivity analysis, parametric programming

Module 3:

Nonlinear programming problem, Kuhn-Tucker conditions, min cost flow problem, max flow problem, CPM/PERT

Module 4:

Scheduling and sequencing, single server and multiple server models, deterministic inventory models, probabilistic inventory control models, geometric programming

Module 5:

Competitive models, single and multi-channel problems, sequencing models, dynamic programming, flow in networks, elementary graph theory, game theory simulation

References

1. H.A. Taha, *Operations Research: An Introduction*, PHI, 2008.
2. H.M. Wagner, *Principles of Operations Research*, PHI, Delhi, 1982.
3. J.C. Pant, *Introduction to Optimisation: Operations Research*, Jain Brothers, Delhi, 2008.
4. Hitler Libermann, *Operations Research*, McGraw Hill, 2009.
5. Pannerselvam, *Operations Research*, Prentice Hall of India, 2010.
6. Harvey M. Wagner, *Principles of Operations Research*, Prentice Hall of India, 2010.

CO-PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	2	1	1	1	2	2	2	3
CO2	3	3	2	3	2	1	1	1	2	2	2	2
CO3	3	2	2	3	2	1	1	1	2	2	2	2
CO4	2	3	3	3	2	1	1	2	3	2	2	2
CO5	3	2	3	3	3	2	2	2	2	2	3	3

Note: Scale – 3 = Strong, 2 = Medium, 1 = Slight.

Course Name: Cost Management of Engineering Project

Course code: MECE302D
Contact: 3:0:0
Total Contact Hours: 36
Credit: 3

Course Outcomes

At the end of this course, masters will be able to:

CO1: Understand theories and practices of strategic cost management.

CO2: Analyze project stages, prepare network diagrams, and manage project execution.

CO3: Explain cost behaviour, profit planning, and management costing techniques.

CO4: Apply cost management tools and techniques in engineering projects.

CO5: Use quantitative techniques (LP, PERT/CPM, Simulation) for effective cost management.

Course Content

Module 1:

Introduction and overview of the strategic cost management process, cost concepts in decision-making (relevant cost, differential cost, incremental cost, opportunity cost). Objectives of a costing system; inventory valuation; creation of a database for operational control; provision of data for decision-making.

Module 2:

Project: meaning, different types, importance of project management, cost overrun centres, stages of project execution (conception to commissioning). Technical and non-technical activities, detailed engineering activities, pre-project clearances and documents. Project team roles, project site data, project contracts (types and contents), project cost control. Bar charts and network diagrams, project commissioning (mechanical and process).

Module 3:

Cost behavior and profit planning, marginal costing vs absorption costing, break-even analysis, cost-volume-profit analysis. Standard costing, variance analysis, pricing strategies, Pareto analysis, target costing, life cycle costing, costing of service sector, just-in-time approach, material requirements.

Module 4:

Planning, enterprise resource planning (ERP), total quality management (TQM), theory of constraints. Activity-based cost management, benchmarking, balanced scorecard, value-chain analysis. Budgetary control, flexible budgets, performance budgets, zero-based budgets. Measurement of divisional profitability, pricing decisions including transfer pricing.

Module 5:

Estimation of spectra from finite-duration observations of signals. Nonparametric and parametric methods for power spectrum estimation, minimum variance spectral estimation, eigen analysis algorithms for spectrum estimation.

Module 6:

Quantitative techniques for cost management: linear programming, PERT/CPM, transportation problems, assignment problems, simulation, learning curve theory.

References

1. *Cost Accounting: A Managerial Emphasis*, Prentice Hall of India, New Delhi.
2. Charles T. Horngren and George Foster, *Advanced Management Accounting.*
3. Robert S. Kaplan and Anthony A. Alkinson, *Management & Cost Accounting.*
4. Ashish K. Bhattacharya, *Principles & Practices of Cost Accounting*, A.H. Wheeler Publisher.
5. N.D. Vohra, *Quantitative Techniques in Management*, Tata McGraw Hill.

CO-PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	3	3	2	1	2	2	2
CO2	2	3	2	2	2	1	1	1	2	1	2	3
CO3	3	2	3	2	2	2	2	1	1	2	2	2
CO4	2	2	3	3	2	1	1	2	2	2	1	2
CO5	2	3	3	2	3	2	1	2	2	2	2	3

Note: Scale – 3 = Strong, 2 = Medium, 1 = Slight.