# MK UNIVERSITY

## PATAN, GUJARAT

**ESTABLISHED BY THE GUJARAT GOVT.** **RECOGNIZED BY UGC UNDER SECTION 2(f) OF UGC ACT,1956**

MK University, Patan
Faculty of Engineering Technology,
Department of Electronics & Communication Engineering

| M. TECH (ELECTRONICS & COMMUNICATION ENGINEERING) SEM-I | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SR NO. | COURSE TYPE | COURSECODE | COURSE NAME | LECTURE (HRS.)/WEEK | PRACTICAL (HRS.)/WEEK | CREDITS | EXAMINATION | | TOTAL MARKS |
| | | | | | | | INTERNAL | EXTERNAL | |
| 1 | MAJOR | MTECE101 | ADVANCED MATHEMATICS FOR ENGINEERS | 4 | 0 | 4 | 40 | 60 | 100 |
| 2 | MAJOR | MTECE102 | ADVANCED DIGITAL SIGNAL PROCESSING | 4 | 2 | 6 | 90 | 60 | 150 |
| 3 | MAJOR | MTECE103 | ADVANCED COMMUNICATION SYSTEMS | 4 | 2 | 6 | 90 | 60 | 150 |
| 4 | MINOR | MTECE104 | RESEARCH METHDOLOGY & TECHNICAL COMMUNICATION | 4 | 0 | 4 | 40 | 60 | 100 |
| 5 | SEC | MTECE105 | ENTERPRENURSHIP DEVELOPMENT | 4 | 0 | 4 | 40 | 60 | 100 |
| TOTAL | | | | 20 | 4 | 24 | 300 | 300 | 600 |

| M. TECH (ELCETRONICS & COMMUNICATION ENGINEERING) SEM-II | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SR NO. | COURSE TYPE | COURSE CODE | COURSE NAME | LECTURE (HRS.)/WEEK | PRACTICAL (HRS.)/WEEK | CREDITS | EXAMINATION | | TOTAL MARKS |
| | | | | | | | INTERNAL | EXTERNAL | |
| 1 | MAJOR | MTECE201 | VLSI DESIGN & VERIFICATION | 4 | 2 | 6 | 90 | 60 | 150 |
| 2 | MAJOR | MTECE202 | EMBEDDED & REAL TIME SYSTEMS | 4 | 2 | 6 | 90 | 60 | 150 |
| 3 | MAJOR | MTECE203 | ADVANCED ANTENNA & RF ENGINEERING | 4 | 2 | 6 | 90 | 60 | 150 |
| 4 | MINOR | MTECE204 | IOT & SENSOR NETWORKS | 4 | 0 | 4 | 40 | 60 | 100 |
| 5 | VAC | MTECE205 | BUSINESS COMMUNICATION-I | 2 | 0 | 2 | 0 | 50 | 50 |
| TOTAL | | | | 18 | 6 | 24 | 310 | 290 | 600 |

M. TECH (ELECTRONICS & COMMUNICATION ENGINEERING) SEM-III

| SR NO. | COURSE TYPE | COURSE CODE | COURSE NAME | LECTURE (HRS.)/ WEEK | PRACTICAL (HRS.)/ WEEK | CREDITS | EXAMINATION | | TOTAL MARKS |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | INTERNAL | EXTERNAL | |
| 1 | MAJOR | MTECE301 | ADVANCED MICROWAVE ENGINEERING | 4 | 2 | 6 | 90 | 60 | 150 |
| 2 | MAJOR | MTECE302 | AI & MACHINE LEARNING FOR ECE | 4 | 2 | 6 | 90 | 60 | 150 |
| 3 | MINOR | MTECE303 | MOOC/SWAYAM COURSE | 3 | 0 | 3 | 100 | 00 | 100 |
| 4 | VAC | MTECE304 | DISSERTATION PHASE-I | 0 | 8 | 8 | 100 | 100 | 200 |
| TOTAL | | | | 11 | 12 | 23 | 380 | 220 | 600 |

M. TECH (ELECTRONIS & COMMUNICATION ENGINEERING) SEM-IV

| SR NO. | COURSE TYPE | COURSE CODE | COURSE NAME | LECTURE (HRS.)/ WEEK | PRACTICAL (HRS.)/ WEEK | CREDITS | EXAMINATION | | TOTAL MARKS |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | INTERNAL | EXTERNAL | |
| 1 | MAJOR | MTECE401 | INDUSTRY SEMINARS/WORKSHOPS/INTERNSHIP | 0 | 2 | 2 | 50 | 00 | 50 |
| 2 | MINOR | MTECE402 | COMPREHENSIVE VIVA VOCE | 0 | 2 | 2 | 50 | 00 | 50 |
| 3 | MAJOR | MTECE403 | DISEERTATION PHASE-II | 0 | 16 | 16 | 200 | 200 | 400 |
| 4 | VAC | MTECE404 | BUSINESS COMMUNICATION-II | 2 | 0 | 2 | 00 | 50 | 50 |
| TOTAL | | | | 2 | 20 | 22 | 300 | 250 | 550 |

## SEMESTER-I

**SUBJECT CODE: MTECE101**

**SUBJECT NAME: ADVANCED MATHEMATICS FOR ENGINEERS**

**Course Objectives:**

- To provide a rigorous mathematical foundation for advanced engineering modeling and analysis.
- To bridge theoretical mathematics with practical engineering applications.
- To develop problem-solving skills using analytical and computational tools.
- To prepare students for research and development in engineering domains requiring mathematical sophistication.

**Course Outcomes:** At the end of the course students shall be able to

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|---|---|
| CO1 | Formulate and solve engineering problems using advanced techniques in linear algebra and tensor analysis. |
| CO2 | Apply partial differential equations (PDEs) and transform methods to model dynamical systems and boundary value problems. |
| CO3 | Use variational calculus and optimization methods for engineering design and control problems. |
| CO4 | Analyze stochastic systems and uncertainty propagation using probability theory and statistical methods. |

| Unit | Content | Credit | Weightage |
|---|---|---|---|
| I | **Advanced Linear Algebra & Tensors for Engineers**<br>○ Review of vector spaces, eigenvalues, SVD, Jordan form<br>○ Matrix decompositions (LU, QR, Cholesky, Schur)<br>○ Tensor algebra: notation, operations, invariants<br>○ Tensor applications: stress-strain, inertia, constitutive models<br>○ Numerical linear algebra (conditioning, iterative solvers)<br>• **Applications:** Structural analysis, continuum mechanics, control systems, data compression. | 1 | 25% |
| II | **Partial Differential Equations & Transform Methods**<br>○ Classification of PDEs (elliptic, parabolic, hyperbolic)<br>○ Separation of variables, eigenfunction expansions<br>○ Green's functions for ODEs and PDEs<br>○ Integral transforms (Fourier, Laplace, Hankel) for PDEs<br>○ Introduction to finite element and finite | 1 | 25% |

| | | | |
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| | volume concepts<br>• **Applications:** Heat transfer, wave propagation, fluid dynamics, signal processing. | | |
| III | **Calculus of Variations & Optimization**<br>○ Functional derivatives, Euler–Lagrange equation<br>○ Constraints (Lagrange multipliers, isoperimetric problems)<br>○ Direct methods (Ritz, Galerkin)<br>○ Optimal control theory (Pontryagin's principle, Hamiltonian formulation)<br>○ Convex optimization basics (gradient descent, KKT conditions)<br>• **Applications:** Optimal design, trajectory optimization, energy minimization, control systems. | 1 | 25% |
| IV | **Stochastic Processes & Uncertainty Quantification**<br>○ Probability spaces, random variables, distributions<br>○ Stochastic processes (Brownian motion, Poisson process, Markov chains)<br>○ Itô calculus basics (stochastic differential equations)<br>○ Uncertainty quantification (Monte Carlo, polynomial chaos, sensitivity analysis)<br>○ Statistical estimation and regression for engineering data<br>• **Applications:** Risk analysis, reliability engineering, random vibrations, financial engineering, signal noise modelling | 1 | 25% |

**TEXT BOOKS:**


- Kreyszig, E. – *Advanced Engineering Mathematics* (10th ed.) – Wiley.
- Strang, G. – *Linear Algebra and Its Applications* (5th ed.) – Cengage.
- Arfken, G.B., Weber, H.J., Harris, F.E. – *Mathematical Methods for Physicists* (7th ed.) – Academic Press.
- J.N. Reddy – *Applied Functional Analysis and Variational Methods in Engineering* – McGraw-Hill.
- Papoulis, A., & Pillai, S.U. – *Probability, Random Variables and Stochastic Processes* (4th ed.) – McGraw-Hill.


**REFERENCE BOOKS:**


- Riley, K.F., Hobson, M.P., Bence, S.J. – *Mathematical Methods for Physics and Engineering* (3rd ed.) – Cambridge.
- Gelfand, I.M., & Fomin, S.V. – *Calculus of Variations* – Dover.
- Oksendal, B. – *Stochastic Differential Equations: An Introduction with Applications* (6th ed.) – Springer.
- Holmes, M.H. – *Introduction to Numerical Methods in Differential Equations* – Springer.
- Gould, P. – *Introduction to Linear Elasticity* (for tensor applications) – Springer.

**ONLINE RESOURCES:**

- Coursera:
    - *Mathematics for Engineers Specialization* (The Hong Kong University of Science and Technology)
    - *Data Science Math Skills* (Duke University)

**SUBJECT CODE: MTECE102**

**SUBJECT NAME: ADVANCED DIGITAL SIGNAL PROCESSING**

**Course Objectives:**

- To provide an in-depth understanding of advanced digital signal processing techniques and algorithms.
- To develop skills in designing and implementing multirate, adaptive, and statistical signal processing systems.
- To apply DSP techniques in communication, speech, image, and biomedical signal processing.
- To prepare students for research and development in real-time DSP systems and emerging applications.

**Course Outcomes:** At the end of the course students shall be able to

| | |
|---|---|
| CO1 | Analyze and design multi rate signal processing systems for bandwidth and computational efficiency. |
| CO2 | Implement adaptive filtering algorithms for noise cancellation, equalization, and system identification. |
| CO3 | Apply statistical signal processing methods for signal estimation, detection, and spectral analysis. |
| CO4 | Design and implement DSP algorithms for real-world applications in communications, audio, and biomedical domains. |

| Unit | Content | Credit | Weightage |
|---|---|---|---|
| I | **Multi rate Signal Processing & Filter Banks**<br>**Topics:**<br>• **Sampling Rate Conversion:** Up-sampling, Down-sampling, Fractional Rate Conversion<br>• **Polyphase Decomposition** and Efficient Structures<br>• **Multi rate Filter Banks:** Analysis and Synthesis<br>• **Quadrature Mirror Filters (QMF), Perfect Reconstruction Filter Banks**<br>• **Applications:** Sub-band Coding, Wavelet Transform, Communication Systems | 1 | 25% |
| II | **Adaptive Signal Processing**<br>**Topics:**<br>• **Adaptive Filter Structures:** FIR, IIR, Lattice Filters<br>• **LMS and RLS Algorithms:** Convergence, Stability, Computational Complexity<br>• **Applications:** Noise Cancellation, Echo Cancellation, Channel Equalization<br>• **Blind Adaptive Algorithms:** CMA, Sato | 1 | 25% |

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|---|---|---|---|
| | Algorithm<br>• **Neural Network-Based Adaptive Filtering** | | |
| III | **Statistical Signal Processing**<br>**Topics:**<br>• **Random Signals & Stochastic Processes:** Autocorrelation, Power Spectral Density<br>• **Wiener Filtering & Linear Prediction**<br>• **Spectral Estimation:** Periodogram, Blackman-Tukey, AR/MA/ARMA Modeling<br>• **Detection & Estimation Theory:** MAP, ML, MMSE Estimators<br>• **Applications:** Radar, Sonar, Biomedical Signal Analysis | 1 | 25% |
| IV | **DSP in Modern Applications**<br>**Topics:**<br>• **Real-Time DSP Implementation:** Fixed-Point Arithmetic, Overflow Handling<br>• **DSP for Communications:** OFDM, MIMO, Synchronization<br>• **Audio & Speech Processing:** MFCC, Noise Reduction, Compression<br>• **Image & Video Processing:** 2D Filtering, Compression, Enhancement<br>• **Hardware Platforms:** DSP Processors, FPGA, Embedded Implementation | 1 | 25% |

**TEXT BOOKS:**

- Proakis, J.G., & Manolakis, D.G. – *Digital Signal Processing: Principles, Algorithms, and Applications* – Pearson.
- Oppenheim, A.V., & Schafer, R.W. – *Discrete-Time Signal Processing* – Pearson.
- Haykin, S. – *Adaptive Filter Theory* – Prentice Hall.
- Vetterli, M., Kovačević, J., & Goyal, V.K. – *Foundations of Signal Processing* – Cambridge.

**REFERENCE BOOKS:**

- Mitra, S.K. – *Digital Signal Processing: A Computer-Based Approach* – McGraw-Hill.
- Diniz, P.S.R. – *Adaptive Filtering: Algorithms and Practical Implementation* – Springer.
- Kay, S.M. – *Fundamentals of Statistical Signal Processing* – Prentice Hall.
- Lyons, R.G. – *Understanding Digital Signal Processing* – Pearson.

**ONLINE RESOURCES:**

- NPTEL: *Advanced Digital Signal Processing* (IIT Madras, IIT Kharagpur)
- Coursera: *Digital Signal Processing Specialization* (École Polytechnique Fédérale de Lausanne)
- edX: *Signal Processing and Systems* (MITx)
- IEEE Xplore: Journals – *IEEE Transactions on Signal Processing*, *IEEE Signal Processing Letters*
- MATLAB/Simulink: DSP System Toolbox, Signal Processing Toolbox, Simulink
- Python Libraries: NumPy, SciPy, Librosa, PySDR

**PRACTICAL LIST:**

**1.** Multi rate System Design

- Task: Design a 3-level wavelet decomposition and reconstruction system using filter banks. Apply to image compression and evaluate PSNR.

2. Adaptive Noise Cancellation

- Task: Implement an LMS-based adaptive noise canceller for speech enhancement. Use real recorded noisy speech and evaluate SNR improvement.

3.Spectral Analysis of Non-Stationary Signals

- Task: Use Short-Time Fourier Transform (STFT) and Wigner-Ville Distribution to analyze chirp and EEG signals. Compare time-frequency resolution.

4. Real-Time DSP Implementation

- Task: Implement a real-time FIR filter on a DSP kit (TI C6713/STM32) or FPGA. Process audio input in real-time and analyze latency and throughput.

**SUBJECT CODE: MTECE103**

**SUBJECT NAME: ADVANCED COMMUNICATION SYSTEMS**

**Course Objectives:**

- To provide an advanced understanding of modern digital communication techniques, modulation schemes, and system performance analysis.
- To analyze and design wireless communication systems, including MIMO, OFDM, and spread spectrum technologies.
- To study advanced topics in coding, synchronization, and equalization for reliable communication in fading channels.
- To prepare students for research and development in 5G/6G, satellite, optical, and software-defined radio systems.

**Course Outcomes:** At the end of the course students shall be able to

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|---|---|
| CO1 | Analyze and design advanced digital modulation and demodulation schemes for AWGN and fading channels. |
| CO2 | Model and evaluate performance of MIMO, OFDM, and spread spectrum systems. |
| CO3 | Design and implement channel coding, synchronization, and equalization techniques for reliable communication. |
| CO4 | Apply advanced communication concepts to modern systems like 5G, satellite, and cognitive radio networks. |

| Unit | Content | Credit | Weightage |
|---|---|---|---|
| I | **Advanced Digital Modulation & Demodulation**<br>**Topics:**<br>• **Review of Digital Modulation:** ASK, PSK, FSK, QAM<br>• **Continuous Phase Modulation (CPM), GMSK**<br>• **Non-Coherent Detection, Differential Modulation**<br>• **Performance Analysis in AWGN & Fading Channels:** BER, SER, Outage Probability<br>• **Optimum Receivers:** Matched Filter, Maximum | 1 | 25% |

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| | Likelihood Detection<br>• **Applications:** Satellite Communication, Deep Space Communication | | |
| II | **MIMO & OFDM Systems**<br>**Topics:**<br>• **MIMO Channel Capacity:** Rayleigh & Rician Channels<br>• **Space-Time Coding:** Alamouti Scheme, OSTBC, V-BLAST<br>• **Beamforming & Spatial Multiplexing**<br>• **OFDM Principles:** IFFT/FFT, Cyclic Prefix, PAPR Reduction<br>• **OFDMA, SC-FDMA**<br>• **Applications:** 4G/5G, Wi-Fi 6, Massive MIMO | 1 | 25% |
| III | **Channel Coding & Advanced Receiver Techniques**<br>**Topics:**<br>• **Advanced Channel Coding:** Turbo Codes, LDPC, Polar Codes<br>• **Iterative Decoding:** BCJR Algorithm, Belief Propagation<br>• **Synchronization:** Carrier, Symbol, Frame Synchronization<br>• **Equalization:** Linear, Decision Feedback, Adaptive Equalizers<br>• **Blind Equalization & Channel Estimation**<br>• **Applications:** Optical Communication, Underwater Acoustic Communication | 1 | 25% |
| IV | **Emerging Communication Technologies**<br>**Topics:**<br>• Cognitive Radio & Dynamic Spectrum Access<br>• Ultra-Wideband (UWB) Communication<br>• Millimeter Wave & Terahertz Communication<br>• Visible Light Communication (VLC)<br>• Satellite & Deep Space Networks<br>• Software-Defined Radio (SDR) Implementation | 1 | 25% |

**TEXT BOOKS:**


- Proakis, J.G., & Salehi, M. – *Digital Communications* – McGraw-Hill.
- Goldsmith, A. – *Wireless Communications* – Cambridge University Press.
- Tse, D., & Viswanath, P. – *Fundamentals of Wireless Communication* – Cambridge.
- Haykin, S. – *Digital Communication Systems* – Wiley.


**REFERENCE BOOKS:**


- Rappaport, T.S. – *Wireless Communications: Principles and Practice* – Prentice Hall.
- Barry, J.R., Lee, E.A., & Messerschmitt, D.G. – *Digital Communication* – Springer.
- Sklar, B. – *Digital Communications: Fundamentals and Applications* – Pearson.
- Molisch, A.F. – *Wireless Communications* – Wiley-IEEE Press.


**ONLINE RESOURCES:**

- NPTEL: *Advanced Digital Communication* (IIT Bombay, IIT Kharagpur)
- Coursera: *Wireless Communications Specialization* (University of Colorado Boulder)
- edX: *Communication Systems* (MITx), *5G for Beginners* (NYU)
- IEEE Xplore: *IEEE Transactions on Communications*, *IEEE Wireless Communications Letters*
- GNU Radio: Open-source SDR platform
- MATLAB: Communications Toolbox, 5G Toolbox, WLAN Toolbox

**PRACTICAL LIST:**

- 1.Digital Modulation & BER Analysis
  Task: Implement and compare BER performance of BPSK, QPSK, 16-QAM, and 64-QAM in AWGN and Rician fading channels using MATLAB.
- 2. MIMO-OFDM System Simulation
  Task: Simulate a 4x4 MIMO-OFDM system with zero-forcing and MMSE equalizers. Analyze spectral efficiency and BER under frequency-selective fading.
- 3.Turbo Code Implementation
  Task: Design a turbo encoder and iterative decoder (MAP/Log-MAP). Evaluate performance over AWGN and Rayleigh channels and plot BER vs. Eb/N0.
- 4. SDR-Based Cognitive Radio
  Task: Using GNU Radio and USRP, implement energy detection-based spectrum sensing and demonstrate adaptive modulation switching between BPSK and QPSK.

**SUBJECT CODE: MTECE104**

**SUBJECT NAME: RESEARCH METHDOLOGY AND TECHNICAL COMMUNICATION**

**Course Objectives:**

- To equip engineering graduates with a structured approach to scientific inquiry and problem-solving.
- To develop proficiency in selecting and applying appropriate research methods for engineering investigations.
- To enhance technical communication skills for academia and industry.
- To foster an understanding of research ethics, scholarly publishing, and lifelong learning in research.

**Course Outcomes:** At the end of the course students shall be able to

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| CO1 | Formulate a research problem, conduct systematic literature reviews, and develop a viable research proposal. |
| CO2 | Design and execute appropriate research methodologies (experimental, numerical, analytical) with consideration for ethics and data integrity. |
| CO3 | Apply statistical tools and software for data analysis, interpretation, and validation of research findings. |
| CO4 | Produce high-quality technical documents (research papers, proposals, theses) and deliver effective technical presentations. |

| Unit | Content | Credit | Weightage |
|---|---|---|---|
| I | **Foundations of Engineering Research & Problem Formulation**<br>• **Topics:**<br>○ Philosophy of research: inductive vs. | 1 | 25% |

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|---|---|---|---|
| | deductive reasoning, scientific method in engineering.<br>◦ Types of engineering research: fundamental, applied, experimental, computational, empirical.<br>◦ Problem identification and formulation: research gap analysis.<br>◦ Literature review strategies: databases (Scopus, Web of Science, IEEE Xplore), citation management tools (Zotero, Mendeley), critical analysis of literature.<br>◦ Developing a research proposal: objectives, scope, significance, and work plan.<br>• **Applications:** Thesis topic selection, grant proposal writing, project planning. | | |
| II | **Research Design, Methods & Ethics**<br>• **Topics:**<br>◦ Research design: experimental, quasi-experimental, case study, modeling & simulation.<br>◦ Data collection methods: sensors, surveys, instrumentation, simulation outputs.<br>◦ Design of Experiments (DoE): factorial design, Taguchi methods, response surface methodology.<br>◦ Research ethics: plagiarism, fabrication/falsification, authorship, informed consent.<br>◦ Ethical approval process and responsible conduct of research (RCR).<br>• **Applications:** Planning a lab/field experiment, setting up a CFD/FEA study, survey design. | 1 | 25% |
| III | **Data Analysis, Statistics & Software Tools**<br>• **Topics:**<br>◦ Data preprocessing: outlier detection, missing data, normalization.<br>◦ Descriptive and inferential statistics: hypothesis testing (t-test, ANOVA), confidence intervals.<br>◦ Regression analysis: linear, multiple, logistic.<br>◦ Introduction to multivariate analysis and machine learning for engineering data.<br>◦ Software tools: MATLAB/Python (NumPy, SciPy, pandas), R, MiniTab.<br>◦ Data visualization principles: effective graphs, charts, and plots. | 1 | 25% |

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| | • **Applications:** Analyzing experimental results, validating computational models, interpreting sensor data. | | |
| IV | **Technical Communication & Research Dissemination**<br>• **Topics:**<br>○ Structure of technical documents: research papers, theses, technical reports.<br>○ Writing strategies: clarity, conciseness, coherence, and argument development.<br>○ Graphical abstracts, data presentation, and table/figure design.<br>○ Oral presentations: conference talks, thesis defense, poster design.<br>○ Publication process: journal selection, peer review, responding to reviewers.<br>○ Intellectual Property Rights (IPR): patents, copyrights, licensing.<br>○ Research dissemination: repositories, academic social networks (ResearchGate, LinkedIn), and impact metrics (h-index, citations).<br>• **Applications:** Paper writing, thesis compilation, conference presentation, patent filing. | 1 | 25% |

**TEXT BOOKS:**


- Kothari, C.R. – *Research Methodology: Methods and Techniques* (4th ed.) – New Age International.
- Day, R.A., and Gastel, B. – *How to Write and Publish a Scientific Paper* (9th ed.) – Greenwood.
- Montgomery, D.C. – *Design and Analysis of Experiments* (10th ed.) – Wiley.
- Alley, M. – *The Craft of Scientific Writing* (4th ed.) – Springer.


**REFERENCE BOOKS:**


- Bordens, K.S., and Abbott, B.B. – *Research Design and Methods: A Process Approach* (11th ed.) – McGraw-Hill.
- Wallwork, A. – *English for Writing Research Papers* (2nd ed.) – Springer.
- Box, G.E.P., Hunter, J.S., and Hunter, W.G. – *Statistics for Experimenters* (2nd ed.) – Wiley.
- IEEE Author Center Guides – *IEEE Publication Services and Products Board*.
- Laplante, P.A. – *Technical Writing: A Practical Guide for Engineers and Scientists* – CRC Press.


**ONLINE RESOURCES:**

- edX Courses:
  1. *"Principles of Statistical Analysis"* (Microsoft)
  2. *"How to Write and Publish a Scientific Paper"* (KU Leuven)

## SEMESTER-II

**SUBJECT CODE: MTECE201**

**SUBJECT NAME: VLSI DESIGN AND VERIFICATION**

**Course Objectives:**

- To provide a comprehensive understanding of modern VLSI design flow from system specification to physical layout.
- To develop skills in RTL design, synthesis, static timing analysis, and physical design using industry-standard tools.
- To introduce verification methodologies including SystemVerilog, UVM, and formal verification techniques.
- To prepare students for careers in ASIC/FPGA design, verification, and physical implementation in the semiconductor industry.

**Course Outcomes:** At the end of the course students shall be able to

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|---|---|
| CO1 | Design and synthesize digital circuits using HDLs (Verilog/System Verilog) for FPGA and ASIC targets. |
| CO2 | Perform static timing analysis, power optimization, and physical design of CMOS digital circuits. |
| CO3 | Develop verification environments using System Verilog and UVM for functional verification of complex digital systems. |
| CO4 | Apply low-power design techniques and understand DFT and physical verification concepts for tape-out readiness. |

| Unit | Content | Credit | Weightage |
|---|---|---|---|
| I | **Digital Design with HDLs & Synthesis**<br>**Topics:**<br>• **Verilog/System Verilog:** RTL coding, behavioral vs. structural modeling<br>• **Combinational & Sequential Design:** FSMs, pipelines, data path design<br>• **Logic Synthesis:** Constraints, technology mapping, optimization<br>• **FPGA Implementation:** Architecture, mapping, place-and-route<br>• **ASIC vs. FPGA Design Flow**<br>• **Tools:** Xilinx Vivado, Intel Quartus, Synopsys Design Compiler | 1 | 25% |
| II | **CMOS Circuit Design & Physical Layout**<br>**Topics:**<br>• **CMOS Fabrication Process:** CMOS n-well, p-well, SOI<br>• **CMOS Inverter:** Static and dynamic characteristics, noise margins<br>• **Combinational & Sequential CMOS Circuits**<br>• **Physical Design:** Floor planning, placement, | 1 | 25% |

| | | | |
|---|---|---|---|
| | routing, clock tree synthesis<br>• **DRC, LVS, and Parasitic Extraction**<br>• **Tools:** Cadence Virtuoso, Mentor Graphics Calibre | | |
| III | **Verification Methodologies with System Verilog & UVM**<br>**Topics:**<br>• **System Verilog for Verification:** Data types, classes, randomization, coverage<br>• **UVM Architecture:** Components, phases, sequences, drivers, monitors<br>• **Assertion-Based Verification:** SVA (System Verilog Assertions)<br>• **Functional Coverage and Scoreboard Design**<br>• **Emulation & Hardware Acceleration**<br>• **Tools:** Mentor QuestaSim, Synopsys VCS, Cadence Incisive | 1 | 25% |
| IV | **Advanced Topics & Design for Testability**<br>**Topics:**<br>• **Low-Power Design Techniques:** Clock gating, power gating, DVFS<br>• **Design for Testability (DFT):** Scan insertion, ATPG, BIST<br>• **Formal Verification:** Equivalence checking, model checking<br>• **Mixed-Signal Design Considerations**<br>• **System-on-Chip (SoC) Integration**<br>• **Emerging Technologies:** 3D ICs, FinFET, AI accelerators | 1 | 25% |

**TEXT BOOKS:**


- Rabaey, J.M., Chandrakasan, A., & Nikolić, B. – *Digital Integrated Circuits: A Design Perspective* – Pearson.
- Palnitkar, S. – *System Verilog for Verification* – Springer.
- Weste, N.H.E., & Harris, D.M. – *CMOS VLSI Design: A Circuits and Systems Perspective* – Pearson.
- Bhasker, J. – *A Verilog HDL Primer* – Star Galaxy Publishing.


**REFERENCE BOOKS:**


- Smith, M.J.S. – *Application-Specific Integrated Circuits* – Addison-Wesley.
- Sutherland, S., Mills, D. – *Verilog and System Verilog Gotchas* – Springer.
- Mead, C., & Conway, L. – *Introduction to VLSI Systems* – Addison-Wesley.
- Bergeron, J. – *Writing Testbenches using System Verilog* – Springer.


**ONLINE RESOURCES:**

- NPTEL: *VLSI Design* (IIT Madras, IIT Kharagpur)
- Coursera: *VLSI CAD Part I & II* (University of Illinois)
- edX: *FPGA Design for Embedded Systems* (University of Colorado)
- IEEE Xplore: *IEEE Transactions on VLSI Systems*, *IEEE Design & Test*
- EDA Tools: Xilinx Vivado (free), Intel Quartus (free), Cadence (academic licenses)

- Open Source: OpenROAD, Yosys, GTKWave

**PRACTICAL LIST:**

- 1.RTL Design & FPGA Implementation
- Task: Design a UART controller with FIFO in Verilog. Synthesize and implement on FPGA (Basys3/Nexys). Verify using serial terminal.
  1. CMOS Layout & Simulation
- Task: Design and layout a 4x1 MUX using CMOS in Cadence Virtuoso. Perform pre- and post-layout simulation and compare delays.
- UVM Testbench Development
- Task: Create a UVM testbench for a PCIe endpoint model. Implement sequences, functional coverage, and assertions for packet integrity.
  1. Low-Power & DFT Implementation
- Task: Integrate clock gating and scan chain insertion in a previously designed ALU. Use Synopsys DFT Compiler and TetraMAX for ATPG.

**SUBJECT CODE: MTECE202**

**SUBJECT NAME: EMBEDDED AND REAL TIME SYSTEMS**

**Course Objectives:**

- To provide an in-depth understanding of embedded system architecture, design methodologies, and real-time operating systems.
- To develop skills in designing, programming, and optimizing embedded systems for real-time applications.
- To study scheduling algorithms, task synchronization, and performance analysis in real-time systems.
- To prepare students for careers in embedded software development, IoT, automotive systems, and industrial automation.

**Course Outcomes:** At the end of the course students shall be able to

| | |
|---|---|
| CO1 | Design and implement embedded systems using microcontrollers, RTOS, and peripheral interfaces. |
| CO2 | Apply real-time scheduling algorithms and analyze system performance using timing constraints. |
| CO3 | Develop and optimize embedded firmware for low-power, safety-critical, and networked applications. |
| CO4 | Integrate embedded systems with IoT platforms, automotive networks, and industrial communication protocols. |

| Unit | Content | Credit | Weightage |
|---|---|---|---|
| I | **Embedded System Architecture & Design**<br>**Topics:**<br>• **Embedded System Components:** Microcontrollers, MPUs, DSPs, Memory, Peripherals<br>• **System-on-Chip (SoC) and FPGA-based Embedded Systems**<br>• **Embedded Design Lifecycle:** Requirements, | 1 | 25% |

| | | | |
|---|---|---|---|
| | Modeling, Implementation, Testing<br>• **Interfacing:** GPIO, ADC/DAC, Timers, PWM, Communication Interfaces (UART, SPI, I2C)<br>• **Power Management & Low-Power Design Techniques**<br>• **Tools:** ARM Cortex-M Development Kits, STM32CubeIDE, Keil MDK | | |
| II | **Real-Time Operating Systems (RTOS) & Scheduling**<br>**Topics:**<br>• **RTOS Concepts:** Tasks, Semaphores, Mutexes, Queues, Mailboxes<br>• **Task Scheduling:** Rate Monotonic, Earliest Deadline First (EDF), Priority Inheritance<br>• **Kernel Services:** Interrupt Handling, Context Switching, Memory Management<br>• **RTOS Implementation:** FreeRTOS, Zephyr, VxWorks, µC/OS<br>• **Performance Metrics:** Response Time, Jitter, Latency, Throughput<br>• **Real-Time Linux & POSIX RT Extensions** | 1 | 25% |
| III | **Embedded Software Development & Optimization**<br>**Topics:**<br>• **Embedded C/C++ Programming:** Bit manipulation, ISRs, DMA<br>• **Compiler Optimizations:** Loop unrolling, inline functions, memory alignment<br>• **Debugging & Profiling:** JTAG, SWD, Logic Analyzers, Performance Counters<br>• **Firmware Security:** Secure boot, encryption, secure firmware updates<br>• **Model-Based Design with MATLAB/Simulink**<br>• **Hardware/Software Co-Design** | 1 | 25% |
| IV | **Advanced Embedded Applications & Communication**<br>**Topics:**<br>• **IoT Embedded Systems:** MQTT, CoAP, LoRaWAN, NB-IoT<br>• **Automotive Embedded Systems:** CAN, LIN, AUTOSAR<br>• **Industrial Communication:** Modbus, PROFINET, EtherCAT<br>• **Wireless Embedded Systems:** Bluetooth Low Energy, Zigbee, Thread<br>• **Safety-Critical Systems:** DO-178C, IEC 61508, MISRA C<br>• **Edge AI & Embedded Machine Learning (TinyML)** | 1 | 25% |

**TEXT BOOKS:**

- Barr, M., & Massa, A. – *Programming Embedded Systems* – O'Reilly.
- Buttazzo, G.C. – *Hard Real-Time Computing Systems* – Springer.
- Noergaard, T. – *Embedded Systems Architecture* – Elsevier.
- Wolf, W. – *Computers as Components: Principles of Embedded Computing System Design* – Morgan Kaufmann.

**REFERENCE BOOKS:**

- Simon, D.E. – *An Embedded Software Primer* – Pearson.
- Laplante, P.A. – *Real-Time Systems Design and Analysis* – Wiley.
- Yiu, J. – *The Definitive Guide to ARM Cortex-M Processors* – Elsevier.
- Ganssle, J. – *The Art of Designing Embedded Systems* – Newnes.

**ONLINE RESOURCES:**

- NPTEL: *Embedded Systems Design* (IIT Kharagpur, IIT Bombay)
- Coursera: *Embedded Systems Specialization* (University of Colorado Boulder)
- edX: *Real-Time Embedded Systems* (UT Austin), *Introduction to IoT* (Curtin University)
- IEEE Xplore: *IEEE Transactions on Embedded Computing Systems, IEEE Embedded Systems Letters*
- Platforms: ARM Developer, STMicroelectronics STM32Cube, Espressif IoT Development Framework
- Simulation: QEMU, Simulink Embedded Coder, Wireshark for protocol analysis

**PRACTICAL LIST:**

- 1.Embedded System Design with STM32
- Task: Build a digital oscilloscope using STM32's ADC and DMA. Display waveform on TFT screen and export data via USB-CDC.
    1. RTOS-Based Multi-Tasking System
- Task: Implement a real-time data logger with FreeRTOS using SD card and RTC. Tasks include sensor sampling, file writing, and status display.
- Optimized Embedded Control System
- Task: Develop a closed-loop motor control system using PID and PWM. Use CMSIS-DSP for filter implementation and analyze CPU load using profiling tools.
    1. IoT-Enabled Embedded System
- Task: Create a Wi-Fi-enabled environmental monitor using ESP32. Stream sensor data to a cloud dashboard (ThingSpeak/Ubidots) and implement OTA updates.

**SUBJECT CODE: MTECE203**

**SUBJECT NAME: ADVANCED ANTENNA AND RF ENGINEERING**

**Course Objectives:**

- To provide an advanced understanding of antenna theory, design principles, and radiation mechanisms for modern wireless systems.
- To develop skills in designing, simulating, and measuring antennas and RF circuits for various frequency bands and applications.
- To analyze and design RF/microwave components including filters, amplifiers, mixers, and matching networks.
- To prepare students for research and development in 5G/6G antennas, MIMO systems, radar, and satellite communication technologies.

**Course Outcomes:** At the end of the course students shall be able to

| | |
|---|---|
| CO1 | Design and analyze various antenna types including microstrip, array, and wideband antennas using electromagnetic simulation tools. |
| CO2 | Model and design RF/microwave passive and active components using S-parameters and impedance matching techniques. |
| CO3 | Analyze and optimize MIMO antenna systems, beamforming networks, and phased arrays for modern wireless applications. |
| CO4 | Conduct antenna measurements, evaluate performance metrics, and integrate antennas into communication and radar systems. |

| Unit | Content | Credit | Weightage |
|---|---|---|---|
| I | **Antenna Theory & Design Fundamentals**<br>**Topics:**<br>• **Review of Antenna Fundamentals:** Radiation patterns, gain, directivity, polarization, impedance bandwidth<br>• **Antenna Parameters:** Return loss, VSWR, efficiency, Friis transmission equation<br>• **Wire Antennas:** Dipole, monopole, loop antennas<br>• **Aperture Antennas:** Horn, slot, reflector antennas<br>• **Microstrip Antennas:** Patch, PIFA, design equations, feeding techniques<br>• **Tools:** CST Studio Suite, ANSYS HFSS, FEKO | 1 | 25% |
| II | **Antenna Arrays & Phased Arrays**<br>**Topics:**<br>• **Array Theory:** Linear, planar, and circular arrays<br>• **Array Factor, Beamforming, and Beam Steering**<br>• **Phased Array Antennas:** Time delay vs. phase shift, scanning limitations<br>• **Smart Antennas:** Adaptive arrays, digital beamforming | 1 | 25% |

| | | | |
|---|---|---|---|
| | • **MIMO Antennas:** Diversity, mutual coupling, correlation coefficient<br>• **Applications:** Radar, satellite, 5G massive MIMO | | |
| III | **RF/Microwave Circuit Design**<br>**Topics:**<br>• **Transmission Lines & Waveguides:** Smith chart, impedance matching<br>• **S-Parameters & Network Analysis**<br>• **RF Passive Components:** Filters, couplers, power dividers, baluns<br>• **RF Active Components:** LNA, PA, mixers, oscillators<br>• **Low-Noise & Power Amplifier Design**<br>• **Tools:** Keysight ADS, AWR Microwave Office, Simulink RF Blockset | 1 | 25% |
| IV | **Advanced Antenna Systems & Measurements**<br>**Topics:**<br>• **Wideband & Multiband Antennas:** Fractal, log-periodic, Vivaldi antennas<br>• **Reconfigurable Antennas:** Frequency, pattern, polarization reconfiguration<br>• **Millimeter-Wave & THz Antennas**<br>• **Antenna Measurement Techniques:** Anechoic chamber, near-field/far-field, gain measurement<br>• **EMC/EMI Considerations in Antenna Design**<br>• **Antennas for IoT, UAVs, and Wearable Systems** | 1 | 25% |

**TEXT BOOKS:**


- Balanis, C.A. – *Antenna Theory: Analysis and Design* – Wiley.
- Pozar, D.M. – *Microwave Engineering* – Wiley.
- Stutzman, W.L., & Thiele, G.A. – *Antenna Theory and Design* – Wiley.
- Ludwig, R., & Bretchko, P. – *RF Circuit Design: Theory and Applications* – Pearson.


**REFERENCE BOOKS:**


- Collin, R.E. – *Foundations for Microwave Engineering* – Wiley-IEEE Press.
- Volakis, J.L. – *Antenna Engineering Handbook* – McGraw-Hill.
- Gonzalez, G. – *Microwave Transistor Amplifiers: Analysis and Design* – Pearson.
- Kraus, J.D., & Marhefka, R.J. – *Antennas for All Applications* – McGraw-Hill.


**ONLINE RESOURCES:**

- NPTEL: *Antenna Theory & Practice* (IIT Bombay, IIT Kharagpur)
- Coursera: *RF and Millimeter-Wave Circuit Design* (Eindhoven University)
- edX: *Antennas: From Theory to Practice* (EPFLx)
- IEEE Xplore: *IEEE Transactions on Antennas and Propagation*, *IEEE Microwave Magazine*
- Simulation Tools: CST Studio Suite (student license), ANSYS HFSS (academic), Keysight ADS (trial)
- Measurement Resources: ARRL Antenna Book, online Smith chart tools

**PRACTICAL LIST:**

- 1.Microstrip Antenna Design & Simulation
- Task: Design, simulate, and optimize a dual-band microstrip antenna for Wi-Fi (2.4/5 GHz). Fabricate using PCB and measure return loss with VNA.
    1. Phased Array Beamforming Simulation
- Task: Simulate an 8-element phased array antenna with beam steering from –30° to +30°. Analyze sidelobe levels and beamwidth variation.
- 3.RF Filter & Amplifier Co-Design
- Task: Design a bandpass filter and a two-stage LNA for a 3.5 GHz 5G band. Simulate cascaded performance including noise figure and linearity.
    1. Reconfigurable Antenna with Measurement
- Task: Design and fabricate a PIN diode-based reconfigurable antenna. Measure S11 and radiation patterns in both states and compare with simulations.

**SUBJECT CODE: MTECE204**

**SUBJECT NAME: IOT AND SENSOR NETWORKS**

**Course Objectives:**

- To provide a comprehensive understanding of IoT architecture, protocols, and sensor network design principles.
- To develop skills in designing and deploying IoT systems with wireless sensor networks, edge computing, and cloud integration.
- To analyze security, scalability, and energy efficiency in IoT networks.
- To prepare students for careers in IoT solution development, smart cities, industrial IoT, and connected healthcare.

**Course Outcomes:** At the end of the course students shall be able to

| | |
|---|---|
| CO1 | Design and implement IoT architectures using sensors, microcontrollers, and communication modules. |
| CO2 | Analyze and apply IoT communication protocols, network topologies, and data management techniques. |
| CO3 | Develop secure, scalable, and energy-efficient IoT solutions with edge and cloud integration. |
| CO4 | Evaluate and deploy IoT systems for real-world applications in smart environments, healthcare, and industry. |

| Unit | Content | Credit | Weightage |
|---|---|---|---|
| I | **IoT Architecture & Sensor Fundamentals**<br>**Topics:**<br>• **IoT Ecosystem:** Layers, components, and reference architectures<br>• **Sensor Types & Characteristics:** Temperature, humidity, motion, environmental, biosensors<br>• **Sensor Interfacing:** Analog/digital, signal conditioning, calibration<br>• **Embedded Platforms for IoT:** Arduino, ESP32, Raspberry Pi, ARM Cortex-M<br>• **IoT Development Boards & Kits** | 1 | 25% |

| | | | |
|---|---|---|---|
| | • **Introduction to Sensor Networks & WSN Architecture** | | |
| II | **IoT Communication Protocols & Networks**<br>**Topics:**<br>• **Short-Range Protocols:** Bluetooth/BLE, Zigbee, Z-Wave, NFC<br>• **Long-Range Protocols:** LoRaWAN, Sigfox, NB-IoT, LTE-M<br>• **IP-Based Protocols:** MQTT, CoAP, HTTP/HTTPS, WebSocket<br>• **Network Topologies:** Star, mesh, cluster-tree, hybrid<br>• **IoT Gateway Design & Edge Computing**<br>• **Network Simulation Tools:** NS-3, OMNeT++, Cooja** | 1 | 25% |
| III | **IoT Data Management, Security & Cloud Integration**<br>**Topics:**<br>• **IoT Data Formats:** JSON, XML, Protocol Buffers<br>• **Edge vs. Cloud Processing:** Fog computing, edge analytics<br>• **IoT Cloud Platforms:** AWS IoT, Azure IoT, Google Cloud IoT<br>• **IoT Security:** Authentication, encryption, secure boot, OTA updates<br>• **Privacy & Trust in IoT Systems**<br>• **Blockchain for IoT Security** | 1 | 25% |
| IV | **Advanced IoT Applications & Case Studies**<br>• **Smart Cities:** Traffic management, waste management, smart grids<br>• **Industrial IoT (IIoT):** Predictive maintenance, SCADA integration, Industry 4.0<br>• **Healthcare IoT:** Wearable devices, remote patient monitoring, telemedicine<br>• **Agricultural IoT:** Precision farming, drone-based monitoring<br>• **IoT in Autonomous Systems:** Drones, autonomous vehicles<br>• **Future Trends:** 6G, AIoT, Digital Twins, IoT standardization | 1 | 25% |

**TEXT BOOKS:**


- Verma, G., & Srivastava, S. – *Internet of Things: Architecture and Design Principles* – McGraw-Hill.
- Shelby, Z., & Bormann, C. – *6LoWPAN: The Wireless Embedded Internet* – Wiley.
- Mazidi, M.A., et al. – *IoT-Based Embedded Systems* – Pearson.
- Bahga, A., & Madisetti, V. – *Internet of Things: A Hands-On Approach* – VPT.


**REFERENCE BOOKS:**

- Stallings, W. – *Wireless Communications & Networks* – Pearson.
- Ganz, A., et al. – *IoT Security: Advances in Authentication* – Wiley.
- Miorandi, D., et al. – *Internet of Things: From Research and Innovation to Market Deployment* – River Publishers.
- Mackenzie, A. – *Wireless Networking: Know It All* – Newnes.


**ONLINE RESOURCES:**

- NPTEL: *Internet of Things* (IIT Kharagpur, IIT Bombay)
- Coursera: *IoT Specialization* (University of California, Irvine)
- edX: *Introduction to IoT* (Curtin University), *IoT Systems and Industrial Automation* (TU Delft)
- IEEE Xplore: *IEEE IoT Journal*, *IEEE Sensors Journal*
- Cloud Platforms: AWS IoT, Azure IoT Hub, Google Cloud IoT (free tiers)
- Simulation: Cisco Packet Tracer IoT, NS-3, Contiki-NG/Cooja

## SEMESTER-III

**SUBJECT CODE: MTECE301**

**SUBJECT NAME: ADVANCED MICROWAVE ENGINEERING**

**Course Objectives:**

- To provide an advanced understanding of microwave circuit theory, transmission lines, waveguides, and electromagnetic wave propagation.
- To design, analyze, and simulate microwave passive and active components for communication, radar, and satellite systems.
- To develop skills in microwave measurement techniques, network analysis, and microwave system integration.
- To prepare students for research and industry roles in RF/microwave engineering, 5G/6G systems, and aerospace applications.

**Course Outcomes:** At the end of the course students shall be able to

| | |
|---|---|
| CO1 | Analyze and design microwave transmission lines, waveguides, and planar structures using electromagnetic theory. |
| CO2 | Design, simulate, and optimize microwave passive components including filters, couplers, and power dividers. |
| CO3 | Model and design microwave active circuits such as amplifiers, oscillators, and mixers using S-parameters and nonlinear analysis. |
| CO4 | Conduct microwave measurements, characterize components, and integrate subsystems for practical applications. |

| Unit | Content | Credit | Weightage |
|---|---|---|---|
| I | **Microwave Transmission Lines & Waveguides**<br>**Topics:**<br>• **Review of TEM, TE, TM Modes**<br>• **Planar Transmission Lines:** Microstrip, Stripline, Coplanar Waveguide (CPW), Slotline<br>• **Waveguide Theory:** Rectangular, Circular, Dielectric Waveguides<br>• **Impedance Matching Techniques:** Quarter-wave, stub matching, broadband matching<br>• **Smith Chart Applications in Microwave Design**<br>• **Tools:** CST Microwave Studio, ANSYS HFSS | 1 | 25% |
| II | **Microwave Passive Components**<br>**Topics:**<br>• **Microwave Resonators:** Cavity, Dielectric, Planar Resonators<br>• **Filters:** Low-pass, High-pass, Bandpass, Bandstop (Chebyshev, Butterworth, Elliptic)<br>• **Couplers:** Directional, Hybrid (Branch-line, Rat-race), Lange Coupler | 1 | 25% |

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|---|---|---|---|
| | • **Power Dividers & Combiners:** Wilkinson, T-junction<br>• **Ferrite Devices:** Circulators, Isolators<br>• **Tools:** Keysight ADS, AWR Microwave Office | | |
| III | **Microwave Active Circuits**<br>**Topics:**<br>• **Microwave Transistors:** HEMT, HBT, MESFET, CMOS RF<br>• **Low-Noise Amplifier (LNA) Design**<br>• **Power Amplifier (PA) Design:** Classes A, B, AB, F, Doherty<br>• **Oscillators:** DRO, VCO, Phase Noise Analysis<br>• **Mixers & Frequency Converters**<br>• **Nonlinear Analysis & Harmonic Balance Simulation** | 1 | 25% |
| IV | **Microwave Systems & Measurements**<br>**Topics:**<br>• **Microwave Measurement Techniques:** VNA calibration, power, noise figure, phase noise<br>• **Antenna Measurements in Microwave Bands**<br>• **Microwave System Integration:** Radar, Satellite Transponders, 5G mmWave Systems<br>• **Microwave Packaging & Thermal Management**<br>• **EMI/EMC Considerations in Microwave Design**<br>• **Emerging Topics:** Metamaterials, SIW, RF MEMS, Microwave Photonics | 1 | 25% |

**TEXT BOOKS:**

- Pozar, D.M. – *Microwave Engineering* – Wiley.
- Collin, R.E. – *Foundations for Microwave Engineering* – Wiley-IEEE Press.
- Ludwig, R., & Bretchko, P. – *RF Circuit Design: Theory and Applications* – Pearson.
- Chang, K. – *RF and Microwave Wireless Systems* – Wiley.

**REFERENCE BOOKS:**

- Gonzalez, G. – *Microwave Transistor Amplifiers: Analysis and Design* – Pearson.
- Matthaei, G., Young, L., & Jones, E.M.T. – *Microwave Filters, Impedance-Matching Networks, and Coupling Structures* – Artech House.
- Bahl, I., & Bhartia, P. – *Microwave Solid State Circuit Design* – Wiley.
- Hong, J.S., & Lancaster, M.J. – *Microstrip Filters for RF/Microwave Applications* – Wiley.

**ONLINE RESOURCES:**

- NPTEL: *Microwave Engineering* (IIT Kharagpur, IIT Bombay)
- Coursera: *RF and Microwave Circuit Design* (Eindhoven University of Technology)
- edX: *Microwave Engineering and Antennas* (EPFLx)
- IEEE Xplore: *IEEE Transactions on Microwave Theory and Techniques, IEEE Microwave Magazine*
- Simulation Tools: ANSYS HFSS, CST Studio Suite, Keysight ADS (student versions)
- Measurement Resources: Keysight/Agilent Application Notes, ARRL RFI Book

**PRACTICAL LIST:**

- 1.Microstrip Line & Waveguide Transition Design
- Task: Design a microstrip to waveguide transition for Ku-band (12–18 GHz). Simulate in HFSS, optimize for bandwidth >2 GHz, and fabricate using aluminum waveguide and PCB.
    1. Bandpass Filter Design & Fabrication
- Task: Design, simulate, and fabricate a microstrip bandpass filter at 3.5 GHz for 5G applications. Measure S-parameters and compare with ADS simulations.
- 3.Low-Noise Amplifier (LNA) Design
- Task: Design an LNA at 10 GHz using GaN HEMT. Simulate gain, noise figure, and stability. Implement on PCB and measure performance with VNA.
    1. Microwave System Integration & Measurement
- Task: Integrate a filter, LNA, and mixer into a receiver front-end at C-band (4–8 GHz). Perform system-level measurements including noise figure and dynamic range.

**SUBJECT CODE: MTECE302**

**SUBJECT NAME: AI AND MACHINE LEARNING FOR ECE**

**Course Objectives:**

- To introduce fundamental and advanced concepts of artificial intelligence and machine learning relevant to electronics and communication engineering.
- To develop skills in applying machine learning algorithms for signal processing, communication systems, and embedded intelligence.
- To implement deep learning models for image, speech, and sensor data processing in real-time embedded systems.
- To prepare students for roles in AI-driven ECE domains such as autonomous systems, IoT intelligence, and smart communication networks.

**Course Outcomes:** At the end of the course students shall be able to

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|---|---|
| CO1 | Apply classical and modern machine learning algorithms for classification, regression, and clustering in engineering datasets. |
| CO2 | Design and implement deep neural networks for computer vision, speech recognition, and signal processing tasks. |
| CO3 | Optimize ML models for embedded deployment using model compression, quantization, and hardware-aware training. |
| CO4 | Develop AI-enhanced solutions for ECE applications such as wireless communication, robotics, IoT, and smart sensing. |

| Unit | Content | Credit | Weightage |
|---|---|---|---|
| I | **Foundations of Machine Learning**<br>**Topics:**<br>• **Introduction to AI & ML:** Supervised vs. unsupervised learning, reinforcement learning<br>• **Linear & Logistic Regression**<br>• **Decision Trees, Random Forests, Gradient Boosting**<br>• **Clustering Algorithms:** K-means, DBSCAN, | 1 | 25% |

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|---|---|---|---|
| | hierarchical clustering<br>• **Dimensionality Reduction:** PCA, t-SNE, LDA<br>• **Evaluation Metrics:** Accuracy, precision, recall, F1-score, ROC-AUC<br>• **Tools:** Python (Scikit-learn, Pandas, NumPy), MATLAB | | |
| II | **Deep Learning Fundamentals**<br>**Topics:**<br>• **Neural Networks:** Perceptron, MLP, activation functions, backpropagation<br>• **Convolutional Neural Networks (CNNs)** for image and signal processing<br>• **Recurrent Neural Networks (RNNs), LSTMs, GRUs** for time-series data<br>• **Autoencoders & Generative Models:** VAEs, GANs<br>• **Transfer Learning & Fine-tuning**<br>• **Frameworks:** TensorFlow, PyTorch, Keras | 1 | 25% |
| III | **ML for Signal Processing & Communications**<br>**Topics:**<br>• **ML for Wireless Communications:** Channel estimation, symbol detection, beamforming<br>• **AI-based Spectrum Sensing & Cognitive Radio**<br>• **Signal Denoising & Enhancement using Deep Learning**<br>• **Speech & Audio Processing:** ASR, speaker identification, noise suppression<br>• **Sensor Data Analytics for IoT**<br>• **Reinforcement Learning for Network Optimization** | 1 | 25% |
| IV | **Embedded AI & Edge Intelligence**<br>**Topics:**<br>• **Model Optimization:** Pruning, quantization, knowledge distillation<br>• **Hardware for AI:** GPUs, TPUs, NPUs, FPGAs for inference<br>• **Embedded ML Frameworks:** TensorFlow Lite, PyTorch Mobile, ONNX Runtime<br>• **Tiny ML:** Machine learning on microcontrollers (ARM Cortex-M, ESP32)<br>• **AI in Autonomous Systems:** Drones, robotics, ADAS<br>• **Ethics & Explainability in AI** | 1 | 25% |

**TEXT BOOKS:**

- Bishop, C.M. – *Pattern Recognition and Machine Learning* – Springer.
- Goodfellow, I., Bengio, Y., & Courville, A. – *Deep Learning* – MIT Press.

- Haykin, S. – *Neural Networks and Learning Machines* – Pearson.
- Murphy, K.P. – *Machine Learning: A Probabilistic Perspective* – MIT Press.

**REFERENCE BOOKS:**

- Géron, A. – *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow* – O'Reilly.
- Raschka, S., & Mirjalili, V. – *Python Machine Learning* – Packt.
- Zhang, Z. – *Machine Learning for Signal Processing* – Cambridge.
- Sutton, R.S., & Barto, A.G. – *Reinforcement Learning: An Introduction* – MIT Press.

**ONLINE RESOURCES:**

- NPTEL: *Machine Learning* (IIT Madras, IIT Kharagpur)
- Coursera: *Deep Learning Specialization Machine Learning* (Stanford)
- edX: *AI for Everyone Machine Learning with Python* (IBM)
- IEEE Xplore: *IEEE Transactions on Neural Networks and Learning Systems*, *IEEE Signal Processing Magazine*
- Cloud Platforms: Google Colab, Kaggle, AWS SageMaker (free tier)
- Hardware Platforms: NVIDIA Jetson, Google Coral, Raspberry Pi, STM32 AI

**PRACTICAL LIST:**

- 1.Classical ML for Signal Classification
- Task: Use Scikit-learn to classify radio signals (AM, FM, QPSK, etc.) from IQ data. Compare SVM, Random Forest, and XGBoost.
  1. CNN for Image & Signal Recognition
- Task: Train a CNN on the MNIST/CIFAR-10 dataset and adapt it for RF signal classification using spectrograms.
- 3.AI-Based Channel Estimation
- Task: Develop a deep learning model (CNN or RNN) for MIMO channel estimation and compare MSE with LS and MMSE estimators.
  1. TinyML Deployment on Embedded Hardware
- Task: Train a small neural network for gesture recognition using accelerometer data. Deploy on Arduino Nano 33 BLE Sense using TensorFlow Lite.