CURRICULUM FOR M.TECH – RF & MICROWAVE ENGINEERING

FIRST SEMESTER

Course Code	Subject	L	T	P	C
	RF Solid State Devices	3	1	0	4
	Radio Wave Engineering	3	1	0	4
	Computational Electromagnetics	3	1	0	4
	Elective-I (Any one from Group-I)	3	1	0	4
	Elective-II (Any one from Group-II)	3	1	0	4
	Microwave Engineering Laboratory - I	0	0	3	2
	Computational Electromagnetic Laboratory	0	0	3	2
	Seminar -I	0	0	3	2
	Comprehensive Viva Voce-I				2
		Total =	15	5	9	28

SECOND SEMESTER

Course Code	Subject	L	T	P	C
	CMOS RF Circuit Design	3	1	0	4
	Microwave Circuits & Measurements	3	1	0	4
	Advanced Antenna Technology	3	1	0	4
	Elective-III (Any one from Group-III)	3	1	0	4
	Elective-IV (Any one from Group-IV)	3	1	0	4
	Microwave Engineering Laboratory - II	0	0	3	2
	Antenna & Simulations Laboratory	0	0	3	2
	Seminar -II	0	0	3	2
	Comprehensive Viva Voce-II				2
		Total =	15	5	9	28

THIRD SEMESTER

Course Code	Subject	L	T	P	C
	Dissertation Interim Evaluation				10
	Comprehensive Viva -Voce				3
	Seminar on Dissertation				2

Total= 15

FOURTH SEMESTER

Course Code	Subject	L	T	P	C
	Dissertation Open Defense				5
	Dissertation Final Evaluation				20

Total= 25

Grand Total = 96

ELECTIVE-I	**ELECTIVE-II**	**ELECTIVE-III**	**ELECTIVE-IV**
Microwave Signal Processing	RADAR Technology & Counter Measure	EMI & EMC	Adaptive & Smart Antenna
Microstrip Components & Circuits	Modern DCT	Software Radio	Fast Wave Devices
Vacuum Tube Technology for Microwave	Optical & Satellite Communication System	Microwave Remote Sensing	Computational Intelligence
MIC & MMIC	Advanced Electromagnetics	4G Wireless Communications	Radio Navigational Aids

MEC

RF SOLID STATE DEVICE (3-1-0)

Module-I **08hours**

Energy Bands & Current Carriers in Semiconductors, Intrinsic & Extrinsic Semiconductor, Junctions, Carrier Process, Drift-Diffusion, Generation-Recombination

Module-II **12hours**

Microwave Transistor, Tunnel Diode, Microwave Field Effect Transistor

Module-III **12hours**

Transferred Electron Devices, Avalanche Transit Time Devices

Module-IV **08hours**

Optoelectronics, LED, Laser, Photo-detector, Solar Cell

Reference Books:

1. Semiconductor Devices, By Kanaan Kano, Pearson (Chapters: 2, 3, 4, 14)
2. Solid State Electronic Devices, By B G Streetman & S Banerjee , Pearson (Chapters: 3, 4, 5, 8)
3. Semiconductor Physics & Devices, By D A Neamen, Tata Mc Graw Hill (Chapters: 4, 5, 6, 14)
4. Microwave Devices & Circuits, By S Y Liao, Pearson (Chapter: 5, 6, 7, 8)
5. Microwave Semiconductor Devices and their applications, By Watson ,McGraw Hill
6. Microwave Semiconductors, By H.V Shurmer, Wien Oldenbourg

MEC

RADIO WAVE ENGINEERING (3-1-0)

Module-I **08 hours**

Introduction, Maxwell's Equation, Wave Equation: Derivation & Solution, Propagation of plane EM wave through conductors & wave guide

Module-II **12hours**

Dispersion, Scattering, Diffraction & Polarization of EM Waves, Radiating System, Multi-pole Fields & Radiation

Module-III **10hours**

Basics of Wave Propagation, Ground Wave propagation, Space Wave Propagation

Module-IV **10hours**

Sky Wave Propagation, Propagation of Radar Waves

Reference Books:

1. Electromagnetic Waves & Radiating Systems, By Jordan & Balmain, PHI (Chapters: 4, 5, 10, 16, 17)
2. Classical Electrodynamics, By J. D. Jackson, Wiley (Chapters: 7, 9, 10)
3. Antennas & Waves Propagation, By J. D. Kraus, Mc Graw Hill (Chapters: 4, 22, 23, 24, 25)
4. Introduction to Radar Systems, By M. L. Skolnik, Mc Graw Hill (Chapter: 8)

MEC COMPUTATIONAL ELECTROMAGNETICS (3-1-0)

Module-I **06hours**

Introduction to Numerical Methods:

Electromagnetic Problems, Basic Numerical Methods, Solution of Algebraic Equations, Accuracy Consideration and Richardson Extrapolation, Examples

Module-II **10hours**

Finite-Difference Method:

Finite-Difference in One Dimension, A One Dimensional Differential Equation, Finite-Difference in Two Dimensions, Two Dimensional Capacitance Problem, Open Regions, Generalizations, Determination of Eigen values in One Dimension, Waveguide Mode Example, Numerical Evaluation of the Determinant, Iterative Solution Methods

Module-III **12hours**

Finite-Difference Time-Domain Method:

Wave Equation in One Spatial Dimension, Time Quantization, Initial Conditions, Waves in Two and Three Spatial Dimensions, Maxwell's Equations.

Finite Element Method:

Basic Concept of Finite Elements, Finite Elements in One Dimension, Linear Interpolation for Isosceles Right Triangles, Square Elements, General Triangular Elements, High Order Interpolation with Triangles, Nodal Expansions and the weak Formulation, Time Dependent Variables.

Module-IV **12hours**

Method of Moments:

Linear Operators, Approximation by Expansion in Basis Functions, Determination of the parameters, Differential Operators, Integral Operators, Pulse Functions, Parallel Plate Capacitor in Two Dimensions, Analysis of Wire Dipole Antenna, Comparison of FDM, FDTD, FEM, and MoM. Hybrid Computational Methods

Reference Books:

1. Analytical and Computational Methods in Electromagnetics, By R. Garg, Artech House Publication
2. Computational Methods for Electromagnetics and Microwaves, By R.C Booton, Jr, , John Wiley & Sons
3. Computational Methods for Electromagnetics, By A. F. Peterson, S. L. Ray, and R. Mittra, IEEE Press
4. The Finite Element Method in Electromagnetics, By J. M. Jin, John Wiley & Sons
5. The finite difference time domain method for electromagnetis, By K. S. Kunz & R. J. Luebbers, CRC Press
6. Field Computation by Moment Methods, By R. F. Harrington, Macmillan

MEC MICROWAVE SIGNAL PROCESSING (3-1-0)

UNIT-I **08hours**

Multirate Digital Signal Processing: Introduction, Decimation by a Factor D, Interpolation by a Factor I, Sampling Rate Conversion by Rational Factor I/D, Filter Design and Implementation for Sampling-Rate, Multistage Implementation of Sampling Rate Conversion, Sampling Rate Conversion of Band Pass Signal, Application of Multi Rate Signal Processing: Design of Phase Shifters, Implementation of Narrowband Low Pass Filters. Implementation of Digital Filter Banks. Filter Bank and Sub band Filter Applications.

UNIT-II **08hours**

Linear Prediction and Optimum Linear Filters: Innovations Representation of a Stationary Random Process, Forward and Backward Linear Prediction, Solution of the Normal Equations, Properties of the Linear Prediction-Error Filters, AR Lattice and ARMA Lattice- Ladder Filters, Wiener Filter for Filtering and Prediction: FIR Wiener Filter, Orthogonality Principle in Linear Mean-Square Estimation.

UNIT-III **12hours**

Power Spectrum Estimation: Estimation of Spectra from Finite-Duration Observation of Signals, Non Parametric Method for Power Spectrum Estimation: Bartlett Method, Blackman and Turkey Method, Parametric Method for Power Estimation: Yuke-Walker Method, Burg Method, MA Model and ARMA Model.

Higher Order Statics (HOS): Moments, Cumulants, Blind Parameters and Order Estimation of MA & ARMA Systems-Application of Higher Order Statistics.

UNIT-IV **12hours**

Adaptive Signal Processing: Least Mean Square Algorithm, Recursive Least Square Algorithm, Variants of LMS Algorithm: SK-LMS, N-LMS, FX-LMS. Adaptive FIR & IIR Filters, Application of Adaptive Signal Processing: System Identification, Channel Equalization, Adaptive Noise Cancellation, Adaptive Line Enhancer.

Reference Books:

1. Digital Signal Processing, By J.G. Proakis and D.G. Manolakis, Pearson
2. Adaptive Signal Processing, By B. Widrow and Stern, PHI
3. Adaptive Filter, By Simon Haykins, PHI

MEC MICROSTRIP COMPONENTS & CIRCUITS (3-1-0)

Module-I **08hours**

Methods of Microstrip analysis, Losses in Microstrip

Module-II **12hours**

Slot line and Co-planar Waveguide, Coupled Microstrip and Directional Coupler

Module-III **10hours**

Branch line coupler Impedance transformers, Filters, Lumped components

Module-IV **10hours**

Power dividers and combiners, Circulators

Reference Books:

1. Microwave engineering using Microstrip Circuits, By Fooks and Zakarevicius, Prentice Hall
2. Microstrip lines and slotlines, By Gupta,Garg,Bahl and Bhartia, Artech House
3. Foundations for Microstrip Circuit Design, By T. C. Edwards, Wiley & Sons

MEC VACUUM TUBE TECHNOLOGY FOR MICROWAVE (3-1-0)

Module-I **08hours**

High Frequency limitations in conventional tubes, UHF miniature tubes.
Classification of Microwave tubes, O-type and M-type Tubes, Slow wave and Fast-wave devices.
Sub-assemblies of Microwave Tubes: Electron Gun (Parallel flow and convergent beam guns, MIG guns), RF Input/Output Couplers, RF Interaction Structures, Magnetic Focusing structures and Collectors.

Module-II **12hours**

RF-wave and beam interaction: localized and continuous.
Transit time O-type Microwave Tubes: reflex klystrons, Klystrodes, multi-cavity klystrons, traveling wave tube amplifiers, Backward Wave Oscillators, Device operation, gain and efficiency calculations, operational characteristics, design criteria, and future trends. Efficiency enhancement and Boradbanding techniques.

Module-III **10hours**

Electron beam wave interactions. Performance and design principle of amplifiers and oscillators.
Magnetrons: device operation, Pi-mode of operation, strapping, mode jumping, frequency pulling and pushing, Performance Chart and Rickie Diagram. Design and Testing of Magnetrons. Crossed field amplifiers: operating principle, device gain and efficiency. Coaxial Magnetrons, Inverted Coaxial Magnetrons, Frequency Agile, Voltage Tunable Magnetrons, Carcinotrons, Amplitrons.

Module-IV **10hours**

Millimeter wave generation and amplification: Peniotrons, Ubitrons, Gyrotrons and Free Electron Lasers, Application, efficiency and bandwidth enhancements and future trends.

Reference Books:

1. Microwave Devices & Circuits, By S Y Liao, Pearson
2. Microwave Tubes, By A. S. Gilmour, Artech House
3. Microwave Active Devices, Vacuum & Solid State, By M. L. Sisodia, New Age International

MEC MIC AND MMIC (3-1-0)

Module-I **08hours**

MIC Technology – Thick film and Thin film technology, Hybrid MIC's, Monolithic MIC technology

Module-II **12hours**

Analysis of stripline and microstripline, Method of conformal Transformation, Characteristic parameters of strip, Microstrip lines, Microstrip Circuit Design, Impedance transformers, Filters, Lumped constant Microstrip circuits

Module-III **10hours**

Coupled Microstrips and Directional couplers, Even and odd mode analysis, Theory of coupled microstrip Directional couplers, Calculations for a coupled pair of Microstrips, Branch line couplers. Lumped Elements for MIC's Design and fabrication of lumped elements, circuits using lumped elements.

Module-IV **10hours**

Nonreciprocal components for MIC's Microstrip on Ferrimagnetic substrates, Microstrip circulators. Isolators and phase shifters, Design of microstrip circuits – high power and low power circuits

Reference Books:

1. Microwave Devices & Circuits, By S Y Liao, Pearson
2. Microwave Integrated circuits, By Gupta KC and Amarjit Singh - Wiley Easterrn
3. Stripline-like Transmission Lines for Microwave Integrated Circuits, By Bharathi, Bhat, and S.K. Koul New Age International

RADAR TECHNOLOGY & COUNTER MEASURE (3-1-0)

MEC

Module-I **08hours**

Radar Range Equation, Theory of target detection, Targets & Interference, MTI Radar

Module-II **12hours**

Pulse Compression Radar, Detection of Radar signals in noise, Waveform selection

Module-III **10hours**

General Introduction to Electronics Warfare, Intercept Systems. Signal Detection, Analysis and Environment Study

Module-IV **10hours**

Dumb and Smart Jammers, Confusion Reflectors, Target Masking and Decoys, Infrared Countermeasures. ECCM system

Reference Books:

1. Modern Radar System Analysis, By David Barton .K - Artech House
2. Radar Design Principles Signal Processing and The Environment, By Fred Nathanson Mcgraw Hill
3. Introduction to Radar systems, By Skolnik - Mcgraw Hill

MEC

MODERN DCT (3-1-0)

Module-I **10hours**

Formatting & modulation of base band, base band demodulation/detection

Module-II **10hours**

Band-pass Modulation and Demodulation / Detection, Communications Link Analysis

Module-III **10hours**

Synchronization, Multiplexing & Multiple Access

Module-IV **10hours**

Spread Spectrum Techniques, Fading Channels

Reference Books:

1. Digital Communications, By Fundamentals and applications by Bernard Sklar, Pearson
2. Digital Communications, By J. G. Proakis, Mc Graw Hill
3. Principles of Communications, By Taub and Scheling, TMH

OPTICAL & SATELLITE COMMUNICATION SYSTEM (3-1-0)

MEC

Module-I **08hours**

Signal propagation in Optical Fibers, Fiber Optic Components for Communication & Networking

Module-II **12hours**

Modulation and Demodulation, Transmission System Engineering, Fiber Non-Linearity and System Design Considerations

Module-III **10hours**

Satellite Link Design, Propagation Effects, Multiple Access

Module-IV **10hours**

Earth Station Technology, Satellite Navigation and GPS, Satellite Packet Communications

Reference Books:

1. Optical Fiber Communications, By Gerd Keiser, McGraw Hill.
2. Optical Networks: A Practical Perspective, By Rajiv Ramaswami and Kumar N. Sivarajan, Elsevier Morgan Kaufmann Publishers (An Imprint of Elsevier).
3. Satellite Communications, By T. Pratt, C. Bostian, J. Allnutt, John Wiley & Sons
4. Digital Satellite Communications, By Tri.T.Ha, Mc.Graw Hill
5. Satellite Communications Engineering, By Wilbur, L. Pritchand, R. A. Nelson and H.G. Suyderhoud, Pearson Publications

MEC ADVANCED ELECTROMAGNETICS (3-1-0)

Module-I **12hours**

The Dirac Delta & its representation for infinitesimal dipole, magnetic current & magnetic current density, inadequacies in Maxwell's equations, impossibility of TEM in waveguide, dielectric slab waveguide & its application to optical communication, plasma oscillations & wave propagation in plasma, dielectric resonator

Module-II **12hours**

Huygens's principle, Babinet's principle, holography, correlation between circuit theory & field theory, derivation of circuit relations from field theory, Faraday rotation, Schumann resonance, tropo-scatter propagation, earth as a cavity resonator, scattering & diffraction, bridging the gap between electricity & magnetism using relativity, interaction of fields & matter

Module-III **06hours**

Bioelectromagnetics:

Introduction, the axon, retinal optical fibers, heart dipole field, defibrillators & pacemakers, biological fields, electromagnetic hazards & environment

Module-IV **10hours**

Introduction of tensors, Special theory of relativity & its applications in electromagnetics

Reference Books:

1. Electromagnetic Waves & Radiating Systems, By Jordan & Balmain, PHI
2. Classical Electrodynamics, By J D Jackson, Wiley
3. Introduction to Electromagnetic Fields, By C. R. Paul, K. W. Whites, Syed A. Nasar, McGraw Hill
4. Maxwell's Equations & The Principles of Electromagnetism, By R. Fitzpatric, Infinity Science Press LLC
5. Concepts of Modern Physics, By A. Beiser, Mc Graw Hill

MEC MICROWAVE ENGINEERING LABORATORY-I (0-0-3)

1. Study of microwave components
2. Measurement of VSWR in waveguide
3. Measurement of frequency of microwave source
4. Study of attenuator, directional coupler, and magic tee characteristics
5. Measurement of microwave source characteristics: Klystron, Gunn Diode

COMPUTATIONAL ELECTROMAGNETICS LABORATORY (0-0-3)

MEC

1. Simulation of FEM method
2. Simulation of FDM method
3. Simulation of MOM method
4. Simulation of FDTD method
5. Computational complexity & convergence of results comparison of above four methods

MEC CMOS RF CIRCUIT DESIGN (3-1-0)

Module-I **08 hours**

Introduction, Basic concepts in RF Design, Passive RLC networks, Passive IC components

Module-II **12hours**

High frequency amplifier design, Voltage references & biasing, LNA design, Mixers

Module-III **12hours**

RF power amplifier, PLL, Oscillators, Synthesizers

Module-IV **08hours**

Noise, Phase noise, Feedback systems

Reference Books:

1. The Design of CMOS RF Integrated Circuits, By T. H. Lee, Cambridge University Press
2. RF Microelectronics, By B. Razavi, Pearson

MEC MICROWAVE CIRCUITS & MEASUREMENT (3-1-0)

Module-I **08hours**

Introduction to microwave circuit concepts, Relation between [s], [z], [y] parameter

Module-II **08hours**

Microwave circuits & theorems, Impedance matching, Passive microwave components

Module-III **14hours**

Measurement of Wavelength, Frequency and Impedance-Introduction, Equivalent circuit of Cavity wave meters, Typical wave meters, resonant cavities, Methods of frequency measurements direct method - Interpolation method, Standard wave reflectors, Measurement of reflection coefficient, Low, Medium, High VSWR measurements, Standing wave pattern, Slotted Line section and its limitation, Impedance measurement techniques, Reflectometer

Module-IV **10hours**

Vector Network analyzer, Concept and description, Reflection and Transmission measurements, magnitude and Phase, measurement of S- Parameters, SWR and Impedances measurements, errors and corrections

Reference Books:

1. Microwave circuit, By J.L. Altmen, D van Nostrand Co.,Inc.
2. Foundations for microwave engineering, By R. E. Collins., John Wiley & Sons
3. Microwave Circuit Theory and Analysis, By R. N. Ghosh, Mc Graw Hill

MEC ADVANCED ANTENNA TECHNOLOGY (3-1-0)

Module-I **08hours**

Biconical antenna, discone & conical skirt monopole, equiangular spiral antenna, fractal antenna concept & technology, corrugated horn antenna, multimode horn antenna, smart antenna- benefit, drawbacks & design, adaptive beamforming, MANET, array theory, Electrically small & big antenna

Module-II **08hours**

Artificial dielectric lens antenna, Luneburg & Einstein lenses, electrically & physically small antenna, ground plane antenna, sleeve antenna, turnstile antenna, submerged antenna, surface wave & leaky wave antenna, weather-vane antenna, flagpote antenna, chimney antenna, ILS antenna, sugar-scoop antenna, asteroid detection antenna, embedded antenna, plasma antenna

Module-III **10hours**

Microstrip and other planar antennas, Various types of feeding methods for microstrip antenna (Co-axial, Inset, Aperture/Slot Coupled, Proximity coupled and Corporate feeding for Arrays); Analysis of rectangular Patch Antenna, Cavity/ Modal Expansion Technique, microstrip antenna array

Module-IV **14hours**

Conventional Scanning Techniques, Feed Networks for phased Arrays, Frequency Scanned Array Design, Search Patterns

Reference Books:

1. Antennas Theory – Analysis and Design, By C. Balanis, Wiley India Edition
2. Antennas, By J. D. Kraus & others, McGraw Hill-Special Indian Edition
3. Phased Array Antennas, By A. A. Ollinerand G.H. Knittel, Artech House

MEC EMI & EMC (3-1-0)

Module-I **08hours**

Introduction, Natural and Nuclear Sources of EMI / EMC

Module-II **10hours**

EMI from Apparatus, Circuits and Open Area Test Sites

Module-III **10hours**

Radiated and Conducted Interference Measurements and ESD

Module-IV **12hours**

Grounding, Shielding, Bonding and EMI filters, Cables, Connectors, Components and EMC Standards

Reference Books:

1. Engineering Electromagnetic Compatibility, By Dr. V.P. Kodali, IEEE Publication, Printed in India by S. Chand & Co. Ltd.
2. Electromagnetic Interference and Compatibility IMPACT series, IIT – Delhi, Modules 1 –9
3. Introduction to Electromagnetic Compatibility, By C.R. Pal, John Wiley

MEC SOFTWARE RADIO (3-1-0)

Module-I **06hours**

Introduction, Multi Rate Signal Processing

Module-II **09hours**

Digital Generation of Signals

Module-III **09hours**

Analog to Digital and Digital to Analog Conversion, Digital Hardware Choices

Module-IV **16hours**

Object – Oriented Representation of Radios and Network Resources, Case Studies in Software Radio Design

Reference Books:

1. Software Radio: A Modern Approach to Radio Engineering, By Jeffrey H. Reed, PEA Publication
2. Software Defined Radio: Enabling Technologies, By Walter Tuttle Bee, Wiley

MEC MICROWAVE REMOTE SENSING (3-1-0)

Module-I **06hours**

Fundamentals and radiometry

Module-II **09hours**

Radar remote sensing

Module-III **09hours**

Airborne and spaceborne radar systems

Module-IV **16hours**

Application of radar remote sensing, special topics in radar remote sensing

Reference Books:

1. Microwave remote sensing, By Ulaby, F.T., Moore, K.R. and Fung, vol-1,vol-2 Addison-Wesley Publishing
2. Principles and applications of Imaging RADAR, Manual of Remote sensing, vol.2, By Floyd.M.Handerson and Anthony, J. Lewis ASPRS, Jhumurley and sons, Inc.
3. Air and spaceborn radar systems -An introduction, By Philippe Lacomme, Jean clande Marchais, Jean-Philippe Hardarge and Eric Normant, Elsevier publications
4. Introduction to microwave remote sensing, By Iain H.woodhouse
5. Radar foundations for Imaging and Advanced Concepts, By Roger J Sullivan, Knovel, SciTech Pub.
6. Radar Fundamentals, By Ian Faulconbridge, Argos Press

MEC 4G WIRELESS COMMUNICATIONS (3-1-0)

Module-I **10hours**

Wireless Communications and Diversity, Broadband Wireless Channel Modeling

Module-II **10hours**

Cellular Communications, CDMA

Module-III **10hours**

OFDM, MIMO

Module-IV **10hours**

UWB, 3G and 4G Wireless Standards

Reference Books:

1. Fundamentals of Wireless Communications, By D.Tse and P.Viswanath, Cambridge University Press
2. Wireless Communications, By A. Goldsmith, Cambridge University Press
3. MIMO Wireless Communications, By E. Biglieri, Cambridge University Press
4. Wireless Communications: Principles and Practice, By T. S. Rappaport , Prentice Hall

MEC ADAPTIVE & SMART ANTENNA (3-1-0)

Module-I **10hours**

Smart Antennas, DOA Estimation Fundamentals

Module-II **10hours**

Beam Forming Fundamentals

Module-III **10hours**

Integration and Simulation of Smart Antennas

Module-IV **10hours**

Space–Time Processing

Reference Books:

1. Introduction to Smart Antennas, By C. A. Balanis & P. I. Ioannides, Morgan & Claypool Publication
2. Smart Antennas for Wireless Communications IS-95 and Third Generation CDMA Applications, By J. C. Liberti Jr., T. S Rappaport , PTR – PH publishers
3. Smart Antennas, By Lal Chand Godara, CRC Press
4. Smart Antennas Adaptive Arrays Algorithms and Wireless Position Location, By T.S. Rappaport , IEEE Press, PTR – PH publishers

MEC FAST WAVE DEVICES (3-1-0)

Module-I **08hours**

Limitation of slow-wave devices for high power and high frequency applications, Classification and sub-assemblies of fast wave electron beam devices

Module-II **08hours**

Relativistic bunching, waveguide mode and beam-mode dispersion relation, Small-orbit, Large-orbit and quasi-optical configurations

Module-III **10hours**

Excitation of desired mode, Mode suppressions, CRM and Weibel instabilities. Principle of operation, Electron beam RF wave interaction mechanism

Module-IV **14hours**

Performance evaluation and design principles of fast-wave devices like: Gyrotron, gyro-klystron, gyro-Travelling-wave tubes, Slow Wave Cyclotron Amplifier and CARM. Peniotron effects, Ubitron, Free Electron Laser. Application, efficiency and bandwidth enhancements and future trends

Reference Books:

1. Klystron, TWT, Magnetron, CFA, Gyrotron, By A. S. Gilmour, Artech House
2. Electromagnetic Theory & Applications in Beam Wave Electronics, By B. N. Basu, World Scientific

MEC COMPUTATIONAL INTELLIGENCE (3-1-0)

Module-I **08hours**

Introduction to Soft Computing: Soft computing constituents and conventional Artificial Intelligence, Neuro-Fuzzy and Soft Computing characteristics. Fuzzy Sets, Fuzzy Rules and Fuzzy Reasoning: Introduction, Basic definitions and terminology, Set-theoretic operations, MF formulation and parameterization, More on fuzzy union, Intersection and Complement, Extension principle and fuzzy relations, Fuzzy If-Then rules, Fuzzy reasoning. Fuzzy Interference System: Mamdani fuzzy models, Sugeno fuzzy models, Tsukamoto fuzzy models, other considerations.

Module-II **13hours**

Least Square Method for System Identification: System Identification, Basic of matrix manipulations and calculus, Least-square estimator, Geometric interpretation of LSE, Recursive least-square estimator, Recursive LSE for time varying systems, Statistical properties and maximum likelihood estimator, LSE for nonlinear models. Derivative based Optimization: Descent methods, Method of Steepest Descent, Newton's method, Step size determination, Conjugate gradient methods, Analysis of quadratic case, Nonlinear least-square problems, Incorporation of stochastic mechanism. Derivative-free Optimization: Genetic algorithm simulated annealing, Random search, Downhill simplex search.

Module-III **07hours**

Adaptive Networks: Architecture, Back-propagation for feed forward networks, Extended back propagation for recurrent networks, Hybrid learning rule: combining steepest descent and LSE. Supervised Learning Neural Networks: Preceptrons, Adaline, Back propagation multi layer preceptrons, Radial basis function networks. Learning from Reinforcement: Failure is the surest path to success, Temporal difference learning, The art of dynamic programming, Adaptive heuristic critic, Q-learning, A cost path problem, World modeling, Other network configurations, Reinforcement learning by evolutionary computations.

Module-IV **15hours**

Unsupervised Learning and other Neural Networks: Competitive learning networks, Kohonen self-organizing networks, Learning vector quantization, Hebbian learning, Principal component networks, Hopfield network. Adaptive Neuro-Fuzzy Inference Systems: ANFIS architecture, Hybrid learning algorithms, Learning methods that cross-fertilize ANFIS and RBNF, ANFIS as universal approximator, Simulation examples, Extensions and advance topics. Coactive Neuro-Fussy Modeling towards generalized ANFIS: Framework, Neuro functions for adaptive networks, Neuro-Fuzzy spectrum, Analysis of adaptive learning capability.

Reference Books:

1. Neuro-Fuzzy and Soft Computing, By J.S.R. Jng, C.T.Sun and E. Mizutani, PHI
2. Neural Networks, Fuzzy Logic and Genetic Algorithms, S. Rajasekaran, G.A.Vijayalaksmi, PHI.

MEC RADIO NAVIGATIONAL AIDS (3-1-0)

Module-I **10hours**

Navigational Systems, Inertial Navigation

Module-II **10hours**

Global Positioning System (GPS) for Navigation

Module-III **10hours**

Differential GPS and WAAS

Module-IV **10hours**

GPS Navigational Application

Reference Books:

1. Avionics Navigation Systems, By Myron Kavton and Walter Friend, Wiley
2. Global Positioning System Theory and Applications, By Parkinson. BW. Spilker, Progress in Astronautics, Vol. I and II, 1996

MEC MICROWAVE ENGINEERING LABORATORY-II (0-0-3)

1. Study of Waveguide Discontinuities-Inductive and capacitive Diaphragms
2. Determination of Slide Screw Tuner-Equivalent circuit
3. Determination of S-matrix of Directional Coupler, Circulator, Magic Tee
4. Characterization of Waveguide Slotted Array
5. Measurements with Network Analyzer

MEC ANTENNA & SIMULATIONS LABORATORY (0-0-3)

1. Gain measurement of 1) Pyramidal Horn, 2) Conical Horn antennas.
2. Pattern Measurement of 1) Pyramidal Horn, 2) Conical Horn antennas
3. Frequency Scanned Array Characteristics
4. Measurement of Input Impedance of an Antenna
5. Software Simulation and Testing of:
    1. Rectangular Microstrip Antenna, Circular Microstrip antenna.
    2. Micro strip Monopole
    3. Microstrip Tee
    4. Cylindrical Horn antenna, Pyramidal Horn antenna
    5. Microstrip Filters
    6. Microstrip power Dividers, Passive Components
    7. Radar Signals