## M.E. (MICROWAVE ENGINEERING)

### First Semester

#### Theory courses

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Course</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>Credits</th>
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<tbody>
<tr>
<td>MEC1005</td>
<td>Electromagnetic Interference &amp; Electromagnetic Compatibility</td>
<td>3</td>
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<td>MEC1021</td>
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<td>MEC1131</td>
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<td>Breadth Paper I</td>
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#### List of Electives –

- MEC2017  Optical Wireless Communication
- MEC1103  VLSI Design and Applications
- MEC1019  Microelectronic devices and Circuits
- MEC1035  Introduction to Software Defined Radio
- MEC1137  Radar Signal Analysis
- MEC1041  Satellite Based Wireless Communication

#### Sessional / Laboratory

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Course</th>
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<th>Credits</th>
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<td>MEC1022</td>
<td>Antenna Lab.</td>
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<td>Elective – II</td>
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#### List of Electives –

- MEC1004  VLSI Design Lab.
- MEC1006  EMI/EMC Lab

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Total Credits 20.0
Second Semester (Microwave Engg)

Theory Courses:

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<th>No.</th>
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<td>MEC2029</td>
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List of Electives (Choose any one from the following)

- MEC2113 Real Time Embedded System Design
- MEC2015 Optical Networking & DWDM
- MEC2127 Microwave Integrated Circuits
- MEC2137 Wireless Networks
- MEC2141 Wireless Signal Propagation & Fading
- MEC 2171 Microwave Measurement and Materials Characterization

Sessional Courses:

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List of Electives (Choose any one from the following)

- MEC2014 Embedded System Lab.
- MEC2028 Microwave Integrated Circuit Lab

Third Semester

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Fourth Semester

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<td>Thesis</td>
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75 Credits
Module -1:
Introduction:

Module -2:
EMC requirements for Electronic Systems:

Module -3:
Conducted Emission and Susceptibility:

Module -4:
Radiated Emission and Susceptibility:
Simple Emission models for wires and PCB lands: Differential mode versus Common mode currents, Differential mode current emission model, Common mode current emission model, Current probes, Simple susceptibility models for wires and PCB lands: Shielded cables and surface transfer impedance.

Module -5:
Cross talk:
Three conductor transmission lines and crosstalk, Transmission line equations for lossless lines, The per unit length parameters: Homogeneous versus Inhomogeneous media, Wide separation approximation for wires, Numerical methods for other structures, The Inductive-Capacitive Coupling Approximation model: Frequency domain Inductive-Capacitive coupling model, Time domain Inductive-Capacitive coupling model, Lumped circuit approximate models. Shielded
Wires: Per unit length parameters, Inductive and Capacitive Coupling, Effect of Shield grounding, Effect of pigtails, Effects of Multiple shields, MTL model predictions, Twisted wires: Per unit length parameters, Inductive and Capacitive Coupling, Effects of Twist, Effects of Balancing.

**Module -6:**

**Shielding:**

Shielding Effectiveness, Far field Sources: Exact solution, Approximate solution, Near field sources: Near field versus far field, Electric sources, Magnetic sources, Low frequency, magnetic fielding shielding, Effect of Apertures.

**Module -7:**

**System Design for EMC:**

Shielding and Grounding, PCB Design, System configuration and design, Electrostatic Discharge, Diagnostic tools.

**Text Books:**

MEC 1021 ANTENNAS AND DIVERSITY

Module -1:
Aperture Antennas:
Radiation Equations, Rectangular Apertures: Uniform Distribution on an infinite ground plane, Uniform distribution in Space, Circular Apertures: Uniform Distribution on an infinite ground plane, Design Considerations.

Module -2:
Antennas for Wireless Communication I:
Helical, Normal mode, Axial mode, Design procedure, feed design for helical antenna, Horn Antenna; E-Plane, H-Plane, Pyramidal horn, Whip antenna, Discone antenna

Module -3:
Antennas for Wireless Communication II:
Microstrip antenna – Basic Characteristics, Feeding Methods, Method of analysis, Transmission line model and cavity model for rectangular patch antenna, Circular Patch Antenna, Inverted F Antenna, Planar Spiral Antenna.

Module -4:
Antenna Arrays:
Two element and N-element arrays, Linear array with uniform, Binomial distribution and Tchebyscheff distribution, Planar array, Phased array, Adaptive arrays.

Module -5:
Diversity Schemes:
Macroscopic diversity scheme, Microscopic diversity scheme – Space diversity, Field diversity, Polarization diversity, Angle diversity, Frequency diversity and time diversity scheme.

Module -6:
Combining Techniques:
Combining techniques for Macroscopic diversity, Combining techniques for Microscopic diversity – Selective combining, Switched combining, Maximal ratio combining, equal gain combining and feed combining technique.

Module -7:
Smart Antenna:
Introduction, Benefits of Smart Antennas, Structures for Beamforming Systems, Strategies for the coverage and Capacity Improvement, Smart Antenna Algorithms.

Text Books:
2. Wireless Communications, Principles and Practices, Rappaport, PHI
4. Smart Antenna, T. K. Sarkar

**Reference Books:**
1. Antennas, J. D. Kraus, TMH
MEC 1131 ADVANCED ELECTROMAGNETIC ENGINEERING

Module –1:
Plane Wave Functions I:

Module –2:
Plane Wave Functions II:
Partially Filled Waveguide, Dielectric Slab Waveguide, Surface Guided Waves, Modal Expansion of Fields.

Module –3:
Cylindrical Wave Functions I:
The Wave Functions, Circular Waveguide, Radial Waveguides, Circular Cavity, Other Guided Waves.

Module –4:
Cylindrical Wave Functions II:
Sources of Cylindrical Waves, Two Dimensional Radiation, Wave Transformations, Scattering by Cylinders.

Module –5:
Spherical Wave Functions I:
The Wave Functions, Spherical Cavity, Orthogonality Relationships, Space as a Waveguide.

Module –6:
Spherical Wave Functions II:
Other Radial Waveguides, Other Resonators, Sources of Spherical Waves, Wave Transformations, Scattering by Spheres.

Module –7:
Perturbational and Variational Techniques:
Perturbation of Cavity Walls, Cavity Material Perturbations, Waveguide Perturbations, Stationary Formulas for Cavities.

Text Books:

Reference Books:
MEC2017 OPTICAL WIRELESS COMMUNICATION

Module-1:
Introduction to optical wireless communication, Optical Wireless channels, Light sources, Modulators, Detector, Atmospheric transmission limitations, Effect of Rain, Fog, and Mist, Scintillation.

Module-2:

Module-3:

Module-4:

Module-5:
Optical wireless receiver design, Receiver Design Considerations, Photodetection in Reverse-biased Diodes. Choosing the Photodetector, Receiver Noise Consideration, Bit Error Rate and Sensitivity, Bandwidth, Signal Amplification Techniques, Receiver Main Amplifier (RMA). Transceiver Circuit Implementation Technologies:

Module-6:

Module-7:

Text Books:

Ref. Books:
MEC 1103 VLSI DESIGN AND APPLICATIONS

Module -1:
Introduction to VLSI:
Fundamental of VLSI, CMOS Devices Modeling, Simple MOS Large Signal Model (SPICE) Parameters, Small Signal Model for the MOS Transistor, Computer Simulation Model, Sub threshold MOS Model, MOS Switch, MOS Diode/ Active resistor, Current Sink and Sources, Current Mirrors, Current and Voltage Reference, Bandgap Reference, Differential Amps, Cascode Amps, Current Amps.

Module -2:
CMOS Operational Amplifiers and Comparators:

Module -3:
Switched Capacitor Circuits, D/A and A/D:
Switched Capacitor Circuits, Amplifiers and Integrators, Two Phase Switched Capacitor Circuits, First and Second Order Switched Capacitor Circuits, Switched Capacitor Filters, Comparative study of D/A, Parallel and Serial Digital Analog Converters, Serial Analog-Digital Converter, Medium, High Speed Analog-Digital Converter, Over sampling Converter.

Module -4:
Layout Design of CMOS Cell:

Module -5:
VLSI Design Issues:

**Module –6 :**

**Digital Subsystem Design:**
Design of Universal Gate using Pseudo-nMOS Logic, Clocked CMOS Single Bit Adder, Parallel Adder, Transmissions Gate Adders, Carry Look Ahead Adders, Other High Speed Adders, Multipliers, Asynchronous Counter, Synchronous Counter, SRAM Arrays, DRAM, ROM Array, Finite Stets Machines, Multilevel Logic.

**Module –7 :**

**Design Economics and Testing:**

**Text Books:**


**Reference Book:**

Module –1:
Introduction to IC Technology, Overview of MOS and BJT, Threshold Voltage, Body effect, basic DC equations, 2nd order Effect, MOS model, small-signal AC characteristics, CMOS inverter and its DC characteristics, static load MOS inverter, Silicon semiconductor technology, wafer processing, oxidation, epitaxy, deposition, ion implantation, CMOS technology, N-Well and P-Well process and SOI.

Module –2:

Module –3:
Mixed signal VLSI chip basic CMOS circuits, CMOS gate transistor sizing, Power Dissipation, Scaling of MOS Transistor Dimension, MOSFET and BJT Current Mirrors and its applications, Basic Gain Stage, Gain boosting techniques, Super MOS transistor, Primitive analog cell, Linear voltage – current converters, MOS multipliers and resistors, CMOS Bipolar and low voltage, BiCMOS, Op- Amp Design, Instrumentation Design, and Low Voltage Filter, BJT and MOS current mirror circuits and its applications.

Module –4:
CMOS Logic gate design, Fan-in and Fan-out, typical NAND and NOR delays, Transistor sizing, CMOS logic structure, DC analysis of Complementary Logic, BiCMOS logic, Pseudo NMOS, dynamic CMOS logic, Clocked CMOS logic, Pass transistor, CMOS Domino Logic, NP domino logic, Cascode voltage switch logic, source-follower pull-up logic (SFPL), clocking strategy and IO structure.

Module – 5:

Module – 6:

Module – 7:
Introduction to Circuit Modeling Tools, Circuit Descriptions, DC Circuit Analysis, AC Circuit Analysis, Transient Analysis, Advance SPICE Command and Analysis, Diode, JFET and MOSFET (Model, Statement and Parameter).

TEXT BOOKS:
Module - 1:
Introduction to Software radio concepts :
Introduction, need, characteristics, benefits and design principles of Software Radios. Traditional radio implemented in hardware (first generations of 2G cell phones), Software controlled radio (SCR), Software defined radio (SDR), Ideal software radio (ISR), Ultimate software radio (USR)

Module - 2:
Radio frequency implementation issues :
The purpose of RF Front-End, Dynamic range, RF Receiver Front-End Topologies, Enhanced Flexibility of the RF Chain with Software Radios, Importance of Components to Overall performance, Transmitter Architecture and their issues, Noise and Distortion in RF Chain.

Module - 3:
Digital generation of signals:

Module- 4:
A/D & D/A Conversion :
Introduction, Parameters of Ideal Data Converters, Parameters of Practical data Converters, Techniques to improve Data Converter performance, Complex ADC and DAC Architectures.

Module- 5:
Multirate Signal Processing:
Introduction, Sample Rate Conversion Principles, Polyphase Filters, Digital Filter Banks, Timing Recovery in Digital receivers Using Multirate Digital Filters.

Module -6:
Antennas & Antenna Arrays:
Introduction, Benefits of Smart Antennas, Structures for Beamforming Systems, Smart Antenna Algorithms.

Module -7:
Case study in Software radio design:
Introduction, SPEAKEasy, JTRS.
Text Book:

1. Software Radio: A Modern Approach to radio Engineering, Pearson Education Asia, Jeffrey H. Reed
Module -1:
Radar equation, MDS, detection of signal in noise, Receiver noise and signal to noise ratio, prediction of radar range.

Module -2:
Probability density functions, probabilities of detection and false alarm rate, integration of radar pulses, radar cross section of targets, radar cross section fluctuations.

Module -3:
Detection of radar signals:
matched filter, correlation receiver, detection criteria, detectors, integrators and CFAR receivers.

Module -4:
Information from radar signals:
basic radar measurements, theoretical accuracy, ambiguity diagram, pulse compression, target recognition.

Module -5:
Radar clutter:
surface clutter radar equation, land clutter, sea clutter, statistical model for surface clutter, detection of targets in clutter.

Module -6:
Estimation of signals in noise, linear mean square estimation, maximum likelihood estimation, Bays estimators of parameters of linear systems.

Module -7:
Propagation of radar waves:
Forward scattering from earth, scattering from round earth surface, atmospheric refraction, standard and non standard propagation.

Text Book:

MEC 1041 SATELLITE BASED WIRELESS COMMUNICATION

Module -1:
Introduction to Satellite Communications:
Origin, History, Current Technology State and Overview of Satellite System Engineering

Module -2:
Orbital Aspects of Earth Satellites:

Module -3:
Satellite Link Design:

Module -4:
Propagation on Satellite-Earth Paths and Its Influence on Link Design:
Absorptive Attenuation Noise by Atmospheric Gases, Rain Attenuation, Noise due to Rain, Rain Depolarization, Tropospheric Multipath and Scintillation Effects.

Module -5:
Multiple Access Techniques in Satellite Communications:
Frequency Division Multiple Access, FDMA, SCPC, MCPC. Time Division Multiple Access, TDMA: random (ALOHA, S-ALOHA) and time synchronized access. Code Division Multiple Access, CDMA, Fixed and On-demand Assignment.

Module -6:
Satellite Networking:
Advantages and Disadvantages of Multibeam Satellites, Interconnection by Transponder Hopping, Interconnection by On-board Switching, Interconnection by Beam Scanning, On-Board Processing, Intersatellite Links.
Module -7:
Types of Satellite Networks:


Text Books:

2. Satellite Communications, John Willey and Sons, 2000. T. Pratt, C.W. Bostian
Module -1:
Micro electromechanical systems:
Introduction, MEMS Overview, Microfabrication of MEMS: Surface Micromachining, Bulk Micromachining, LIGA, micromachining of polymeric MEMS devices

Module -2:
Fundamentals MEMS Device Physics:

Module -3:
MEMS Materials and fabrication process Modelling:

Module -4:
MEMS Switches:
Switch parameters, basics of switching, Switches for RF and microwave applications, actuation mechanisms for MEMS devices, dynamics of switch operation, MEMS switch design considerations, Microwave Considerations, Material Consideration, Mechanical Considerations modeling and evaluation.

Module -5:
MEMS Inductors and Capacitors:
MEMS Inductors: self and mutual inductance, micromachined inductors, modeling and design issues of planar inductors, variable inductor and polymer based inductor. MEMS Capacitors: MEMS gap tuning capacitor, MEMS area tuning capacitor, Dielectric Tunable capacitors.

Module -6:
MEMS RF applications:
Mems based RF and Microwave circuits: RF Filters, Micromachined Phase shifters, and Micromachined antenna.
Module -7:

MEMS packaging:

MEMS packaging: Role of MEMS packaging, Types of MEMS packaging, Microwave packaging Considerations, Wafer level packaging

Text Books:

1. RF MEMS & Their Applications by Vijay K. Varadan, K. J. Vinoy and K. A. Jose John Wiley & Sons, 2003
2. Introduction to Microelectromechanical Microwave Systems (2nd Edition) by Hector J. De Los Santos, Artech house

Reference Books:

2. Mems Mechanical Sensors Microelectromechanical system series Stephen Beeby/Artech House
MEC 2125 NUMERICAL TECHNIQUES IN ELECTROMAGNETICS

Module -1:
Introduction:
Need for Numerical Solution of Electromagnetic problems, Selection of a numerical method, Classification of Electromagnetic problems, Classification of Solution Region, Classification of Boundary Conditions.

Module -2:
Finite Difference (FD) Methods:

Module -3:
Finite Difference Time Domain (FDTD) Methods:
Yee’s FD algorithms, Accuracy & stability, Lattice truncation condition, Initial fields, Absorbing Boundary conditions for FDTD, Scattering problems.

Module -4:
Integral Equations:
Classification of Integral Equations, Relation between Differential and Integral Equations, Green’s function: definition, Green’s function for free space.

Module -5:
Method of Moments (MoM):
Solution of integral equations using MoM, Quasi-static problems (thin conducting wire, parallel plate capacitor), Dipole antenna current distribution & input impedance, mutual impedance of two short dipoles, Scattering from a dipole antenna.

Module -6:
Finite Element Method:
Finite Element Discretization, Element Governing Equations, Assembling of all Elements, Solving the resulting equations, Typical Applications.

Module -7:
Monte Carlo (MC) methods:
Introduction, Fixed and Floating Random Walks, Markov Chains, Solving typical electromagnetic Problems with random walk and Markov chain methods.

**Text Books:**

MEC 2029 RF CIRCUIT DESIGN

Module -1:
Introduction:

Module -2:
An Overview of RF Filter Design I:
Basic Resonator and Filter Configurations: Filter Type and Parameters, Low-Pass Filter, High Pass Filter, Bandpass and Bandstop Filters, Insertion Loss, Special Filter Realizations: Butterworth –Type, Chebyshev and Denormalization of Standard Low-Pass Design.

Module -3:
An Overview of RF Filter Design II:

Module -4:
Matching and Biasing Network:

Module -5:
RF Transistor Amplifier Design I:
Module -6:
RF Transistor Amplifier Design II:
Constant Gain: Unilateral Design, Unilateral Figure of Merit, Bilateral Design, Operating and Available Power Gain Circles, Noise Figure Circles, Constant VSWR Circles. Broadband, High Power and Multistage Amplifiers.

Module -7:
RF Oscillators and Mixers:

Text Book :

1. RF Circuit Design Theory and Application, Reinhold Ludwig and Pavel Bretchko, Ed. 2004, Pearson Education
MEC2113  REAL TIME EMBEDDED SYSTEM DESIGN

Module - 1:
Introduction to Embedded Systems:
Embedded system overview, Design challenges, Common design metrics, Time-to-market design metric, NRE and unit cost design metrics, Performance design metric, Processor technology, General purpose processors – software and hardware, Application specific processors, IC technology, Semi-custom ASIC.

Module – 2:
Embedded System Processors:
Combinational logic and transistors, RT-level combinational and sequential components, Custom single purpose processor design. RT-level custom single– purpose processor design, Optimization, Optimization of FSMD, Optimization of data path.

Module-3:
Memory:
Write ability and data permanence, memory devices type of memory and basic form, EEPROM, flash memory, SRAM and DRAM, basic DRAM characteristics, memory selection for embedded systems, allocation of memory to the program segment blocks.

Module – 4:
Device and Interrupt service:
Bus models, time multiplexed bus, strobe and handshake protocols, strobe handshake compromise priority arbiter multilevel bus, and architecture.

Module - 5:
Embedded System Peripherals:
Timers, Counters, Watch-dog timers, Example of reaction timer, Watchdog timer, UART, PWM, Controlling a dc motor using a PWM. General purpose processor, ASIP’s and ASIC’s, semiconductor IC’s programmable logic devices of CGD, Processor selection for embedded systems, special purpose processor.

Module – 6:
Interfacing:
Communication basics, Basic protocol concepts, ISA bus protocol, Microprocessor interfacing, I/O addressing, Interrupts, Example of DMA I/O and ISA Bus protocol, Arbitration, Priority arbiter, Daisy-chain arbiter, Parallel, Serial and Wireless
communication, infrared-TRDA, radio frequency, error detection, CAN, USB, Blue tooth, IEEE 802-II, shared memory models

**Module – 7:**

**Digital Camera and Systems:**


**Text Book:**


**Reference Book:**

Module-1:
Optical Network Elements:

Module-2:
Optical Amplifiers:

Module -3:
Optical Networks:

Module -4:

Module -5:
Dispersion Management:
Need for dispersion management, pre-compensation and post compensation technique, Broadband dispersion compensation, Tunable dispersion compensation, Higher order dispersion management, PMD compensation.

Module-6:
Optical Switching:
Photonic packet switching, Bit interleaving, Packet interleaving, OTDM Testbeds.

Module-7 : 
Soliton communication:
Solitons, Soliton Pulses, Soliton parameters, Transmission for ultrafast (UF) OTDM signal using Soliton.

Text Book:

Reference Books:

1. B. Mukherjee, Optical Communication Networks, McGraw Hill.
2. R. Ramaswami and K.N. Sivarajan, Optical Networks: A Practical Perspective, Morgan Kaufmann
MEC 2127 MICROWAVE INTEGRATED CIRCUITS

Module -1:
Introduction to Monolithic Microwave Integrated Circuits (MMICs), their advantages over discrete circuits, MMIC fabrication techniques, Thick and Thin film technologies and materials, encapsulation and mounting of active devices. Microstrips on semiconductor substrates.

Module -2:
Planar transmission lines for MICs. Method of Conformal transformation for microstrip analysis, concept of effective dielectric constant, Effective dielectric constant for microstrip, Losses in Microstrip.

Module -3:
Slot Line Approximate analysis and field distribution, Transverse resonance method and evaluation of slot line impedance, comparison with microstrip line.

Module -4:
Fin lines & Coplanar Lines. Introduction, Analysis of Fin lines by Transverse Resonance Method, Conductor loss in Fin lines . Introduction to coplanar wave guide and coplanar strips.

Module -5:
Lumped Elements for MICs:
Use of Lumped Elements, Capacitive elements, Inductive elements and Resistive elements,

Module -6:
Microwave Solid – State Active Devices for MICs:
Schottky Barrier diode, Pin diode, Varactor diode – structure, characteristics, operation, equivalent circuit, gain expression and output power efficiency and applications. Bipolars, MESFETs and HEMTs

Module -7:
MIC Measurement, Testing and Applications:
MIC measurement system, measurement techniques – S parameter measurement, noise measurement, MIC applications.

Text Book:


Reference Books:

2. Microwave Integrated Circuits, By Ivan Kneppo, J. Fabian, P. Bezousek
Module -1

Wireless Personal Area Networks:
Bluetooth-IEEE 802.15.1: Bluetooth Protocol Stack, Bluetooth Link Type, Bluetooth Security, Network Connection establishment in Bluetooth
ZigBee Technology: ZigBee Components & Network Topologies
Ultra Wideband-IEEE 802.15.3a

Module -2:

Wireless Local Area Networks:
WLAN Technologies, Protocol architecture, Physical layer, Data link layer, Medium access control layer, Interference between Bluetooth and IEEE 802.11, Security of 802.11 systems

Module -3:

Wireless Wide Area Networks:

Module -4:

TCP over wireless network:
Overview of traditional TCP, Impact on the performance of TCP over wireless environment, Link Layer Scheme (Snoop Protocol), The I-TCP protocol, The mobile TCP protocol.

Module -5

IPv6:
IPv4 vs. IPv6, IPv6 addressing, IPv6 header format, IPv6 extension, IPv6 routing architecture, QoS capabilities, IPv6 transition mechanism

Module -6:

Mobile IP:
Mobile IP: New architecture entities, Operation of Mobile IP, Message Format, Agent Discovery, Agent advertisement, Registration, Authentication, Route optimisation, Mobility support for IPV6

Module -7:

Wireless ATM:
WATM services, Reference model, Functions, Radio access layer, Handover, Location management, Access Point Control Protocol.

Text Book:

Reference Books:
1. Mobile communication by J.Schiller, Pearson Education
2. FOROUZAN--------------------------
3. www.ietf.org
   (i) rfc 3513.txt : IPv6 addressing architecture
   (ii) rfc 2460.txt : IPv6 specification
MEC2141 Wireless Signal Propagation and Fading

Module-1
Radio Propagation and Path Loss Models
Free space attenuation, attenuation over reflecting surface, effects of earth curvature, radio wave propagation, propagation path loss models (Okumura model, Hata model, COST 231 model), indoor propagation models.

Module-2
Statistical Multipath Channel Models
Time varying channel impulse response, characteristics of wireless channels, signal fading statistics (Rician distribution, Rayleigh distribution, Lognormal distribution) level crossing rate and average duration of fades, wideband fading models (power delay profile, coherence bandwidth, Doppler spread).

Module-3
Capacity of Wireless Channels
Capacity in AWGN, Capacity of flat fading channels, capacity of frequency selective channels, time invariant channels, time varying channels.

Module-4
Adaptive Modulation and Coding
Adaptive transmission systems, adaptive techniques (variable rate technique, variable power, variable error probability, variable coding technique, hybrid techniques).

Module-5
Diversity and Equalization Techniques
Realization of independent fading paths, receiver diversity, transmitter diversity, equalizer noise enhancements, equalizer types, folded spectrum and ISI free transmission, linear equalizers, adaptive equalizers.

Module-6
Multicarrier Modulation
Data transmission using multiple carriers, mitigation of subcarrier fading, discrete implementation of multicarrier modulation, OFDM, challenges in multicarrier modulation.

Module-7
Multiple Antennas and Space Time Communications
MIMO channel capacity, MIMO diversity gain, Beam forming, diversity-multiplexing trade-off, space time modulation and coding, frequency selective MIMO channel, smart antennas.

Text Book

Reference Books
Module -1:
Electromagnetic Properties of Materials:
Materials Research and Engineering at Microwave Frequencies, Physics for Electromagnetic Materials, General Properties of Electromagnetic Materials, Intrinsic Properties and Extrinsic Performances of Materials

Module -2:
Reflection Methods:

Module -3:
Transmission/Reflection Methods:

Module -4:
Resonator Methods:
Introduction, Dielectric Resonator Methods, Coaxial Surface-Wave Resonator Methods, Split-Resonator Method, Dielectric Resonator Methods Measurement for Surface-Impedance

Module -5:
Resonant Perturbation Methods:

Module -6:
Planar-Circuit Methods:
Introduction, Stripline Methods, Microstrip Methods, Coplanar-Line Methods
Module -7:
Measurement of Permittivity and Permeability Tensors:


Text Book: