COMPUTATIONAL ELECTROMAGNETICS

17ECMC2T1 **Credits: 4**

Lecture: 4 periods/week **Internal assessment: 40 marks**

Semester end examination: 60 marks

Prerequisites: Time-Harmonic Electromagnetic Fields

Course Objectives

To illustrate the concepts electromagneticsand related theorems

- To analyzedifferent problems in electromagnetics
- To illustrate the most common numerical techniques adopted for the electromagnetic modeling of microwave and millimeter-wave circuits and antennas.
- To analyze which method is appropriate for a given problem

Learning Outcomes

Students will be able to

- Understand the concepts of time varying electromagnetic fields
- Understand why numerical methods are needed to solve realistic or practical problems in electromagnetic
- select the most appropriate numerical technique to solve a specific electromagnetic problem
- Apply the efficient numerical method for realistic problems in electromagnetics

UNIT-I

Fundamental concepts: Introduction,Review of Electromagnetic Theory -Electrostatic Fields ,Magnetostatic Fields ,Time-varying Fields,Boundary Conditions,Wave Equations,Time-varying Potentials,Time-harmonic Fields, Classification of EM Problems - Classification of Solution Regions,Classification of Differential Equations, Classification of Boundary Conditions,Some Important Theorems -Superposition Principle,Uniqueness Theorem

UNIT-II

Finite Difference Methods: Introduction, Finite Difference Schemes,Finite Differencing of Parabolic PDEs,Finite Differencing of Hyperbolic PDEs,Finite Differencing of Elliptic PDEs -Band Matrix Method,Iterative Methods,Accuracy and Stability of FD Solutions, Guided Structures -Transmission Lines,Waveguides, Wave Scattering (FDTD) -Yee’s Finite Difference Algorithm, Accuracy and Stability,Lattice Truncation Conditions,Initial Fields, Absorbing Boundary Conditions for FDTD,Finite Differencing for Nonrectangular Systems,Cylindrical Coordinates,Spherical Coordinates,Numerical Integration -Euler’s Rule,Trapezoidal Rule, Simpson’s Rule,Newton-Cotes Rules,Gaussian Rules,Multiple Integration

UNIT-III

Moment Methods: Introduction,Integral Equations - Classification of Integral Equations, Connection Between Differential and Integral Equations, Green's Functions - For Free Space, For Domain with Conducting Boundaries Quasi-Static Problems,Scattering Problems -Scattering by Conducting Cylinder,Scattering by an Arbitrary Array of Parallel Wires, Radiation Problems -Hallen's Integral Equation,Pocklington's Integral Equation,Expansion and Weighting Functions, EM Absorption in the Human Body -Derivation of Integral Equations,Transformation to Matrix Equation (Discretization),Evaluation of Matrix Elements, Solution of the Matrix Equation

UNIT-IV

Finite Element Method: Introduction,Solution of Laplace's Equation -Finite Element Discretization,Element Governing Equations,Assembling of All Elements,Solving the Resulting Equations,Solution of Poisson's Equation-Deriving Element-governing Equations,Solving the Resulting Equations ,Solution of the Wave Equation,Automatic Mesh Generation I — Rectangular Domains ,Automatic Mesh Generation II — Arbitrary Domains -Definition of Blocks,Subdivision of Each Block,Connection of Individual Blocks, Bandwidth Reduction,Higher Order Elements -Pascal Triangle,Local Coordinates,Shape Functions, Fundamental Matrices

Textbooks:

1. Numerical Techniques in Electromagnetics, 2nd Edition, Matthew Sadiku, CRC Press 2001.

2. Computational Methods for Electromagnetics, By A. F. Peterson, S. L. Ray, and R. Mittra, IEEE Press

Reference Books:

1. Computational Methods for Electromagnetics and Microwaves, By R.C Booton, Jr, , John Wiley &Sons
2. The Finite Element Method in Electromagnetics, By J. M. Jin, John Wiley & Sons
3. The finite difference time domain method for electromagnetis, By K. S. Kunz & R. J. Luebbers, CRC Press
4. Field Computation by Moment Methods, By R. F. Harrington, Macmillan