

**FACULTY OF ENGINEERING**

# **Savitribai Phule Pune University**

**Syllabus for the**

**M.E (Electronics & Telecommunications Engineering –Microwave)**

**(2017 Course)**

**(w.e.f. June 2017)**

**M.E. (Electronics and Telecommunications- Microwave)  
2017 Pattern  
Syllabus Structure**

**First Year – Semester I**

Sr.No.	Subject Code	Subject	Examination Scheme						Credits
			L/P	Paper		TW	OR	Total	
				ISA	ESA				
1	504301	Electromagnetics and Antenna Theory	4	50	50	-	-	100	4
2	504302	RF and Microwave Circuits	4	50	50	-	-	100	4
3	504303	Microwave Measurements	4	50	50	-	-	100	4
4	504104	Research Methodology	4	50	50	-	-	100	4
5	504305	Elective I	5	50	50	-	-	100	5
6	504306	Lab Practice I	4	-	-	50	50	100	4
		<b>Total</b>	<b>25</b>	<b>250</b>	<b>250</b>	<b>50</b>	<b>50</b>	<b>600</b>	<b>25</b>

**Elective I:**

1. Signal Processing for Wireless Communications
2. Communication Network
3. Fiber Optic Communication
4. Mathematics for Microwave Engineering

\*LATEX

## First Year – Semester II

Sr.No.	Subject Code	Subject	Examination Scheme					Credits	
			Paper						Total
			L/P	ISA	ESA	TW	OR		
1	504307	Computational Electromagnetics	4	50	50	-	-	100	4
2	504308	RF and MMIC Technology	4	50	50	-	-	100	4
3	504309	Wireless Communication System	4	50	50	-		100	4
4	504310	Elective II	5	50	50	-	-	100	5
5	504311	Lab Practice II	4	-	-	50	50	100	4
6	504312	Seminar I	4	-	-	50	50	100	4
		<b>Total</b>	<b>25</b>	<b>200</b>	<b>200</b>	<b>100</b>	<b>100</b>	<b>600</b>	<b>25</b>

### Elective II :

1. Micro Strip Antennas
2. Smart Antennas
3. Cognitive Radio
4. Remote Sensing and Satellite Image Processing

\*Software Tools

## Second Year – Semester I

Sr.No.	Subject Code	Subject	Examination Scheme					Credits	
			Paper						Total
			L/P	ISA	ESA	TW	OR		
1	604301	EMI and EMC Techniques	4	50	50	-	-	100	4
2	604302	Radar and Satellite Communications	4	50	50	-	-	100	4
3	604103	Elective III	5	50	50	-	-	100	5
4	604304	Seminar II	4	-	-	50	50	100	4
5	604305	Project Stage I	08	-	-	50	50	100	8
		<b>Total</b>	<b>25</b>	<b>150</b>	<b>150</b>	<b>100</b>	<b>100</b>	<b>500</b>	<b>25</b>

### Elective III:

#### For 3 credits

1. Value Education, Human Rights and Legislative Procedures
2. Environmental Studies
3. Energy Studies
4. Disaster Management
5. Knowledge Management
6. Foreign Language
7. Economics for Engineers
8. Engineering Risk – Benefit Analysis
9. Technology Play

#### For 2 credits

1. Optimization Techniques
2. Fuzzy Mathematics
3. Design and Analysis of Algorithms
4. CUDA

**Note:** Syllabus for Elective III is common for all discipline.

\*Elective III will be combination of subjects with 3 credits and 2 credits

## Second Year – Semester II

Sr.No.	Subject Code	Subject	Examination Scheme					Credits	
			Paper						Total
			L/P	ISA	ESA	TW	OR		
1	604306	Seminar III	5	---	---	50	50	100	5
2	604307	Project Work Stage II	20	---	---	150	50	200	20
		<b>Total</b>	<b>25</b>	<b>---</b>	<b>---</b>	<b>200</b>	<b>100</b>	<b>300</b>	<b>25</b>

**504301**

## **Electromagnetics and Antenna Theory**

**Teaching Scheme:**

Lectures: 4 Hrs/Week

**Examination Scheme:**

In Semester: 50 Marks

End Semester: 50 Marks

**Credits:4**

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**Course Objectives:**

- i. The student learns the fundamental solutions of time-varying Maxwell's equations, and applies them to design antennas.
- ii. The student understands radio wave propagation phenomena in modern communication systems, and fundamentals of electromagnetic radiation with application to antenna theory and design.
- iii. Students will be introduced to antennas, their principle of operation, analysis and their applications.
- iv. To lay a background on the fundamentals of antenna theory and various types of antennas including linear wire antennas, loop antennas, antenna arrays, aperture antennas and microstrip antennas.

**Course Outcomes:**

Upon successful completion of this course, students should be able to:

1. Identify, analyze and interpret the fundamental parameters of antennas.
2. Formulate the radiation fields of an antenna, at both near- and far zone; and identify the duality and reciprocity principles.
3. Formulate and analyze the radiation from wire antennas (dipoles, monopoles, loop antennas).
4. Formulate and analyze the antenna arrays.
5. Formulate and analyze the aperture antennas. Identify the field equivalence principle.
6. Formulate and analyze the microstrip antennas.
7. Ability to design and conduct experiments, gather data, analyze and interpret results for investigating antenna engineering problems.

**Module: I**

**(8Hrs)**

**Review Electromagnetic Field Theory:** Maxwell's Equations, Boundary conditions, Wave Equation. Plane waves in lossless and lossy media. Reflection and Refraction, Vector Potentials A and F, Electric and Magnetic current sources M, J, Uniqueness theorem, Field Equivalence Principle: Huygens Principle.

**Module II**

**(10Hrs)**

**Wire Antennas:** Antenna parameters, Linear Antennas, Infinitesimal dipole, small dipole, finite and half wave dipole, loop antenna.

**Antenna Arrays:** Two element array, N-element array Uniform spacing and uniform nonuniform amplitude, binomial array, Dolph -Tschebyscheff's Array, planar and circular array..

### **Module III**

( 8Hrs)

**Aperture Antennas:** Circular Apertures, Rectangular Aperture, Horn Antenna: E-plane, H-Plane pyramidal and conical horn antenna, Reflector Antennas: Plane Reflector, Corner reflector and Parabolic Reflector.

### **Module IV**

(10 Hrs)

**Travelling Wave Antennas:** Long wire, V Antenna, Rhombic Antenna, Broad band Antennas: Helical Antenna, Yagi-Uda of Linear elements, Yagi - Uda Array of Loops, Spiral Antennas, Log-Periodic Antenna.

**Microstrip Antennas:** Basic Characteristics, feeding methods, methods of analysis, rectangular patch, circular patch, quality factor, bandwidth efficiency, input impedance, circular polarization, arrays and feed networks.

### **References:**

- v. Constantine A Balanis, Antenna Theory; Analysis and Design, John Wiley & Sons, Inc, 2007
- vi. John D Kraus, Ronald J Marhefka, Ahmad S Khan, Antennas for All Applications, Tata McGraw-Hill Publishing Company Limited, 2002
- vii. R.C.Johnson and H.Jasik, Antenna Engineering hand book, Mc-Graw Hill, 1984
- viii. I.J.Bhal and P.Bhartia, Micro-strip antennas, Artech house, 1980

## **Electromagnetics and Antenna Theory**

### **Laboratory Assignments/Experiments:**

1. Write MATLAB program to simulate the radiation pattern of the following antennas
  - i. Hertzian Dipole
  - ii. Finite Length Dipole
  - iii. Half Wave Dipole
2. Carry out the Far Field Measurements and Plot the Radiation pattern and find the directivity, gain, effective length for the Half wave dipole
3. Carry out the Far Field Measurements and Plot the Radiation pattern and find the directivity, gain, effective length for the Helix Antenna
4. Write Program for Antenna arrays to plot the radiation pattern for End-Fire, Broadside, Binomial, Tschebyshev's

**504302**

**RF and Microwave Circuits**

**Teaching Scheme:**

Lectures: 4 Hrs/Week

**Examination Scheme:**

In Semester: 50 Marks

End Semester: 50  
Marks

**Credits:4**

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**Course Objectives:**

- 1) To understand and analysis of Transmission Line with smith chart.
- 2) To understand and analysis of Microwave Network using Matrix algebra and Signal Flow Graph.
- 3) To understand and study of Microwave components.
- 4) To understand and analysis of Nonlinearity and Time variance.
- 5) To understand and study of Microwave Semiconductor Devices and modeling.
- 6) To understand and analysis of Microwave Amplifiers design.

**Course Outcomes:**

Upon completion of the course, students will be able to:

1. Determine and use parameters of Transmission Line to analysis and design.
2. Determine and analysis of Microwave Network using Matrix algebra and Signal Flow Graph.
3. Study and Use of Microwave components for different applications.
4. Perform analysis of Nonlinearity and Time variance.
5. To study and understand Microwave Semiconductor Devices and modeling.
6. Perform analysis of Microwave Amplifiers design.

**Module I**

**(8Hrs)**

**Transmission Line Theory**

Lumped element circuit model for transmission line, field analysis, Smith chart, quarter wave transformer, generator and load mismatch, impedance matching and tuning.

**Microwave Network Analysis**

Impedance and equivalent voltage and current, Impedance and admittance matrix, The scattering matrix, transmission matrix, Signal flow graph.

**Module II**

**(10Hrs)**

**Microwave Components**

Microwave resonators, Microwave filters, power dividers and directional couplers, Ferromagnetic devices and components.

**Nonlinearity And Time Variance**

Inter-symbol interference, random process & noise, definition of sensitivity and dynamic range, conversion gain and distortion.



### **Module III**

**(8Hrs)**

#### **Microwave Semiconductor Devices AndModelling**

PIN diode, Tunnel diodes, varactor diode, schottky diode, IMPATT and TRAPATT devices, transferred electron devices, Microwave BJTs, GaAs FETs, low noise and power GaAs FETs, MESFET, MOSFET, HEMT.

### **Module IV**

**(8Hrs)**

#### **Amplifiers Design**

Power gain equations, stability, impedance matching, constant gain and noise figure circles, small signal, low noise , high power and broadband amplifier, oscillators, Mixers design.

#### **References:**

1. S.Y. Liao, "Microwave circuit Analysis and Amplifier Design", Pr entice Hall 1987.
2. R.Ludwig and P.Bretchko, "R. F. Circuit Design", Pearson Education Inc
3. G.D. Vendelin, A.M. Pavoï, U. L. Rohde, "Microwave Circuit Design Using Linear And Non Linear Techniques", John Wiley 1990.
4. D.M.Pozar,, Microwave engineering" ,Wiley, 3<sup>rd</sup> edition.

### **RF and Microwave Circuits**

#### **Laboratory Assignments/Experiments:**

1. Calculate the standing wave ratio and plot the pattern along a slotted line when it is open circuited, short circuited and terminated with matched load.
2. Find the scattering matrix for E, H and E-H planes.
3. Study the operation of ferrite circulator and measure isolation, insertion loss and cross coupling.
4. Design RF transmitter and receiver.
5. Model any one of known RF components.

## **504303                      Microwave Measurements**

### **Teaching Scheme:**

Lectures: 4 Hrs/Week

### **Examination Scheme:**

In Semester: 50 Marks

End Semester: 50  
Marks

**Credits:4**

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### **Course Objective:**

1. To learn the design of transmission line with scattering parameter and circuit analysis.
2. To inculcate the system of Attenuation, RF voltage and noise measurement.
3. To study the elements of Network Analyzer and verification of automatic Network Analyzer
4. To study the calibration of RF power measurement.

### **Course Outcome:**

After successfully completing this course, the student should be able to

1. Understand, plan and execute the properties of transmission lines
2. Implement the method of attenuation and noise measurement.
3. Learn the different operation and measurement by using Network Analyzer.
4. Solve the Practical problem in RF power measurement.

### **Module I**

**(8Hrs)**

#### **Transmission Lines, Scattering Parameters**

Transmission Lines - Basic principles, Structures and Properties of Transmission Lines, lossless wave guides. Scattering Parameters and Circuit Analysis, Uncertainty and Confidence in measurements, Using Coaxial Connectors in Measurement.

### **Module II**

**(10Hrs)**

#### **Attenuation Measurement**

Basic principles, Measurement systems, important considerations when making attenuation measurements.

#### **RF Voltage Measurement**

RF voltage measuring instruments, impedance matching and mismatch errors.

#### **Noise Measurements**

Types of noise, types of noise source, measuring noise, measurement accuracy, mismatch effects, automated noise measurements.

### **Module III**

**(8Hrs)**

#### **Network Analyzers and Spectrum Analyzer**

Measurements and Applications, Elements of network analyzer, MMIC measurement techniques, calibration and verification of automatic network analyzers, spectrum analyzer basic principle, applications of spectrum analyzer.

#### **Module IV**

**(8Hrs)**

#### **RF Power Measurement**

Power sensors, power measurements and calibration, calibration and transfer standards, power splitters, couplers and reflectometers.

#### **References:**

1. Richard Collier & Douglas Skinner, Microwave Measurements, 3rd Edition, IET, 2007
2. Ginzton, EL, Microwave Measurements, McGraw Hill-1957

#### **Microwave Measurements**

#### **Laboratory Assignments/Experiments:**

1. Measure the spectrum of various fundamental signals, harmonics and AM, FM, BPSK modulated signals.
2. Study the Network Analyzer, Carry out the measurements of s-parameter measurement for the various microstrip components.
3. Carry out the attenuation measurement.
4. Carry out the RF Noise measurements.
5. Explain in detail the concept of RF power measurement. Carry out the RF power measurement using microwave bench.  
Write a detailed assignment on uncertainty analysis in various measurements.

**504104**

**Research Methodology**

**Teaching Scheme:**  
**Lectures 4Hrs/ Week**

**Examination Scheme:**  
**Theory :**  
**50 Marks (In Semester)**  
**50 Marks (End Semester)**  
**Credits : 4**

**Course Objectives :**

- Understand some basic concepts of research and its methodologies
- Select and define appropriate research problem and parameters
- Computing model to predict performance of experimental system
- write a research proposal

**Course Outcomes:**

At the end of the course, the students should be able to:

- Frame the problem with the correct research methodology
- Collecting data that accurately addresses the research problem
- Prepare and defend a research proposal

**Module I**

**( 8 Hrs )**

**Research Problem**

Meaning of research problem, Sources of research problem, Criteria / Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

**Module II**

**( 12Hrs )**

**Basic instrumentation**

Instrumentation schemes, Static and dynamic characteristics of instruments used in experimental set up, Performance under flow or motion conditions, Data collection using a digital computer system, Linear scaling for receiver and fidelity of instrument, Role of DSP is collected data contains noise.

**Applied statistics**

Regression analysis, Parameter estimation, Multivariate statistics, Principal component analysis, Moments and response curve methods, State vector machines and uncertainty analysis.

**Module III**

**( 10Hrs )**

## **Modelling and prediction of performance**

Setting up a computing model to predict performance of experimental system, Multi-scale modelling and verifying performance of process system, Nonlinear analysis of system and asymptotic analysis, Verifying if assumptions hold true for a given apparatus setup, Plotting family of performance curves to study trends and tendencies, Sensitivity theory and applications.

### **Module IV**

( 8Hrs )

#### **Developing a Research Proposal**

Format of research proposal, Individual research proposal, Institutional proposal

Proposal of a student– a presentation and assessment by a review committee consisting of Guide and external expert only. Other faculty members may attend and give suggestions relevant to topic of research.

#### **References:**

1. Research methodology: an introduction for science & engineering students, by Stuart Melville and Wayne Goddard
2. Research Methodology: An Introduction by Wayne Goddard and Stuart Melville
3. Research Methodology: A Step by Step Guide for Beginners, by Ranjit Kumar, 2<sup>nd</sup> Edition
4. Research Methodology: Methods and Trends, by Dr. C. R. Kothari
5. Operational Research, by Dr. S.D. Sharma, KedarNath Ram Nath& co.

## **Research Methodology**

### **Laboratory Assignments/Experiments:**

1. Design a typical research problem using scientific method
2. Design a data collection system using digital computer system.
3. Study the various analysis techniques.
4. Design and develop a computing model to predict the performance of experimental system.
5. Develop the following research proposal
  - A. Individual
  - B. Institutional

**504305**

## **Signal Processing for Wireless Communications**

### **ELECTIVE-I**

**Teaching Scheme:**  
**Lectures 4Hrs/ Week**

**Examination Scheme:**  
**Theory :**  
**50 Marks (In Semester)**  
**50 Marks (End**  
**Semester)**  
**Credits : 4**  
**( 8 Hrs )**

#### **Module I**

##### **Spectrum Estimation And Modelling**

Definition, Problem of PSE, Non parametric and parametric spectral estimation, least mean square estimation.

##### **Adaptive Filters**

Introduction to steepest descent adaptive filters, LMS algorithm, application to noise cancellation, RLS algorithm.

#### **Module II**

**( 12Hrs )**

##### **Basics of Signal Detection Theory**

Definition of detection and estimation, review of deterministic and random signal concepts, Transformation of random variables using Gaussian density, Rayleigh density, Cauchy density, Uniform density, Chi squared density, Hypothesis testing, Bayes detection, Max detection, ML detection, Neyman Pearson criterion, Multiple hypothesis testing, composite hypothesis testing, Receiver operating characteristic and performance, Bayes estimation, Max estimation and ML estimation. Radar target detection and parameter estimation, dynamic target tracking.

#### **Module III**

**( 8Hrs )**

##### **Detection of Signals in White Gaussian Noise**

Sign detector and its performance analysis, binary detection problem, matched filters, M-ary communication system, detection of signals with random parameters.

#### **Module IV**

**( 8Hrs )**

##### **Detection of Signals in Coloured Gaussian Noise**

Derivation of correlation structure using an arbitrary orthonormal set, detection of known signals in coloured Gaussian noise, discrete time detection known signals embedded in coloured Gaussian noise.

#### **References:**

1. Introduction to statistical signal processing with application by M.D.Srinath, P.K.Rajasekaran and R.Vishwanathan, Pearson edition
2. Detection theory applications and digital signal processing by Ralph D Hippensteil, CRC press

3. Digital Signal Processing: Principles, Algorithms, And Applications, by John G. Proakis. Publisher, Pearson Education
4. Digital signal processing a practical approach by E Ifeachor and W.Jervis ,Prentice Hall

## **Signal Processing for Wireless Communications**

### **Laboratory Assignments/Experiments:**

1. Implement of Huffman coding and arithmetic coding.
  2. Implement different probability distribution models.
  3. Implement adaptive filters for noise cancellation application.
  4. Implement different spectral estimation algorithm with applications.
  5. Implement various speech codec's.
- Implement image compression using wavelet transform.

**504305**

**Communication Network  
ELECTIVE-I**

**Teaching Scheme:**  
**Lectures 4Hrs/ Week**

**Examination Scheme:**  
**Theory :**  
**50 Marks (In Semester)**  
**50 Marks (End Semester)**  
**Credits : 4**

**Course Objectives:**

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

1. Build an understanding of the fundamental concepts of computer networking.
2. Familiarize the student with the basic taxonomy and terminology of the computer networking area.
3. Introduce the student to advanced networking concepts, preparing the student for entry Advanced courses in computer networking.
4. Allow the student to gain expertise in some specific areas of networking such as the design and maintenance of individual networks.

**Course Outcomes:**

After completing this course the student must demonstrate the knowledge and ability to:

1. Independently understand basic computer network technology.
2. Understand and explain Data Communications System and its components.
3. Identify the different types of network devices and their functions within a network
4. Familiarity with the basic protocols of computer networks, and how they can be used.
5. Understand wireless LAN .

**Module I**

**(8Hrs)**

**Types of Networks:** N/W components, N/W functions, Different networks.

Network design issues: Justifying network, scope, manageability, Architectures, Switching mode, Node placement sizing, link topology and sizing, Routing.

Data in support of Network design and Network design tools.

**Module II**

**(10Hrs)**

**Analysis of loss and delay:** Probability Distributions, M/M/1 queue & Other Queuing system.

System with loss. Erlang function, Poisson's function.

OSI model, Layers in OSI model, TCP / IP protocol suite, Protocols: Ping, FTP, telnet, http (www), SMTP, SNMP, Trace route, TFTP, BOOTP, DNS, NFS, RPC, ICMP, IGMP, ARP, RARP, DHCP etc. TCP header, UDP header, IP header. Real time interactive Audio/Video protocol

**Module III**

**(8Hrs)**

**Data link control:** Framing, Flow control, Noiseless channel, Noisy channel, HDLC, PPP. Multiple Access: Random Access, Controlled Access, Channelization.

Wired LANs: IEEE standards, Standard Ethernet, Changes in the Standards, Fast and Gigabit Ethernet,



## **Module IV**

**(8Hrs)**

**Wireless LANS:** IEEE 802.11, Bluetooth.

Connecting LANS: Connecting devices, Backbone networks, Virtual LANS.

Virtual circuit networks: Architecture and Layers of Frame Relay and ATM. Security services in multimedia networking.

### **References:**

1. Behrouz A. Foruzan, "Data communication and Networking", Tata McGraw-Hill.
2. Andrew S. Tannenbaum, "Computer Networks", Pearson Education
3. Aaron Kershenbaum, "Telecommunication Network Design Algorithms", McGraw Hill, International Editions.
4. William Stallings "Cryptography and Network Security"
5. Stevens, TCP/IP illustrated Volume I and II

### **Communication Network**

#### **Laboratory Assignments/Experiments:**

1. Study wire shark Network Protocol Analyzer Tool.
2. Study of Network Monitoring Tool.
3. Study and Implement Wireless Network Systems.
4. Study and Implement Socket Programming.

**504305**

**Fiber Optic Communication**  
**ELECTIVE-I**

**Teaching Scheme:**  
**Lectures 4Hrs/ Week**

**Examination Scheme:**  
**Theory :**  
**50 Marks (In Semester)**  
**50 Marks (End Semester)**  
**Credits : 4**

**Prerequisite:**

Introduction to communication systems and electromagnetic fields and waves. Specifically students should be familiar with analog and digital communication systems, frequency-division and time-division multiplexing techniques. Maxwell's equations and waveguides

**Course Objectives:**

1. To learn the basic elements of optical fiber transmission link, fiber modes configurations and structures
2. To understand the different kind of losses, signal distortion in optical wave guides and other signal degradation factors
3. To learn the various optical source materials, LED structures, quantum efficiency, Laser diode
4. To learn the fiber optical receivers such as PIN APD diodes, noise performance in photo detector, receiver operation and configuration
5. To learn the fiber optical network components, variety of networking aspects, FDDI, SONET/SDH and operational principles WDM

**Course Outcome:** after completion of the course students will be able to:

1. To apply the knowledge of fibre optical components, links, and systems.
2. Learn system relevant parameters of devices are derived from a physical description, and these parameters form the basis for designing fibre optic links.
3. Understand, describe, analyze, compare the most important devices: light sources, fibres and detectors from both physical and system point of view.
4. Design digital fibre optic links.

**Module I**

**( 12Hrs )**

**Overview of Optical Fiber Systems:**

Block Diagram, Structures, Types, Mode Theory for Circular Waveguides, Modes, Waveguide Equations for SM and MM fibers, Fiber Optic Cables, Attenuation, Signal Distortion in Optical Waveguides, Mode Coupling, Optical Sources, Photo detectors, transmitter and receivers.

**WDM Concepts and Components:**

Operational Principles of WDM, Passive Components: 2 X 2 Fiber Coupler, Scattering Matrix Representation, 2 X 2 Waveguide Coupler, Star Couplers, Mach-Zehnder Interferometer Multiplexers, Fiber Grating Filters, Phased-Array-Based WDM Devices, Tunable Sources, Tunable Filters, System Considerations, Tunable Filter Types.

**Module II**

**( 10Hrs )**

### **Optical Amplifiers:**

Basic Applications and Types of Optical Amplifiers, Amplifier Types, Semiconductor Optical Amplifiers, External Pumping, Amplifier Gain, Erbium-Doped Fiber Amplifiers, Amplification Mechanism, EDFA Architecture, EDFA Power-Conversion Efficiency and Gain, Amplifier Noise, System Applications, Power Amplifiers, In-Line Amplifiers, Preamplifiers, Multichannel Operation, In-Line Amplifier Gain Control, Wavelength Converters, Optical Gating Wavelength Converters, Wave-Mixing Wavelength Converters.

### **Module III**

( 8Hrs )

### **SONET/SDH:**

Introduction, Optical Components, SONET/SDH Networks, SONET/SDH Frames, Virtual Tributaries, STS-N/STM-N Frames, Synchronization and Timing, Maintenance, IP over SONET.

### **Module IV**

( 8Hrs )

**Issues in WDM Optical Networks:** Optical Network Architectures, Issues in Wavelength Routed Networks, Routing and Wavelength Assignment, Wavelength-Convertible Networks, Multifiber Networks, Wavelength Rerouting, Virtual Topology Design, Virtual Topology Reconfiguration, Survivable Networks, Optical Multicast Routing, Network Control and Management, Transmission Impairment, Ring Networks and Traffic Grooming, Virtual Private Networks over WDM Optical Networks.

Introduction to Wavelength routing algorithms

### **References:**

1. G. Keiser, Optical Fiber Communications. Boston: McGraw Hill, 2000.
2. C. Siva Ram Murthy and M. Guruswamy, WDM Optical Networks. New Delhi: Prentice Hall of India, 2002.
3. S. Kartalopoulos, Understanding SONET/SDH and ATM (IEEE Press). New Delhi: Prentice Hall of India, 2001.
4. W. Goralski, Optical Networking and WDM. New Delhi: Tata McGraw Hill, 2001.
5. U. Black, Optical Networks. New Delhi: Pearson Education, 2002.
6. J. Senior, Optical Fiber Communications. New Delhi: Prentice Hall of India, 1992

### **Fiber Optic Communication**

#### **Laboratory Assignments/Experiments:**

1. Study of characteristics of fiber optic LED's, detectors, optical fiber
2. Study of losses in optical fiber
  - a. Propagation, bending, connector losses,
  - b. Effect of misalignment
3. Study of modulation and demodulation
4. Virtual prototype of optical communication system using simulation software
5. Analyze key characteristics of multimode optical communication systems such as Transverse mode profile, effective modal bandwidth, signal spectra, eye diagram etc using simulation software

**504305**

**Elective-I: Mathematics for Microwave Engineering**

**Teaching Scheme:**

Lectures 4 Hrs/Week

**Examination Scheme:**

In Semester: 50 Marks

End Semester: 50 Marks

**Credits:4**

**Course Outcomes:**

On completion of the course, student will be able to

1. exhibit the knowledge of vectors calculus based mathematical aspects.
2. Apply fundamentals of Multiple integrals
3. Solution of partial differential equations.

**Module I**

**( 8Hrs )**

**Multiple Integrals**

Double integrals, triple integrals, application of multiple integrals, change of variables in multiple integrals.

**Vector Calculus**

Differentiation and integration of vectors, space curves, scalar and vector fields, vector operators: Gradient, divergence, curl, vector operator formulae, Cylindrical and spherical polar coordinates, general curvilinear coordinates.

**Module II**

**( 8Hrs )**

**Line, Surface and Volume Integrals**

Line Integrals, connectivity of regions Green's theorem in a plane, Surface integrals, volume integrals, integral forms, Divergence theorem and related theorems, Stokes' theorem and related theorems.

**Module III**

**( 10Hrs )**

**Partial Differential Equations: General and Particular Solutions**

Important partial differential equations, general form of solution, general and particular solutions, the wave equation, uniqueness of solution.

**Module IV**

**( 8Hrs )**

**Partial Differential Equations: Separation Of Variables and Other Methods**

Separation of variables: the general method, Superposition of separated solutions, Separation of variables in polar coordinates, Integral transform methods, Inhomogeneous problems – Green's functions.

**References:**

1. K.F.Riley, M.P.Hobson, S.J.Bence, "Mathematical Methods for Physics and Engineering" 3<sup>rd</sup> edition, Cambridge University Press, 2006
2. I. S. Sokolnikiff, "Mathematical Methods of Physics and Engineering", McGraw Hill

## **Mathematics for Microwave Engineering**

### **Laboratory Assignments/Experiments:**

1. Application of Multiple Integrals.
2. Application of Green's Theorem for Antenna Analysis.
3. Solution of Wave Equation in Cartesian, Cylindrical, and Spherical Coordinate System.
4. Application of integral equations to the solution of Electromagnetic Problem.

**504305**

**Elective-I: LaTeX**

**Teaching Scheme:**

Lectures: 1Hrs/Week

**Examination Scheme:**

**Credits:1**

**Course Objectives:**

The objectives of this course are to :

- Construct documents using LaTeX.

**Course Outcomes:**

On completion of the course, student will be able to

- Create documents/assignments/reports using LaTeX.

LaTeX /Document Structure, Document classes, Packages, The document environment, Book structure.

**References:**

<http://miktex.org/>

<http://www.winedt.com/>

\*For each Subject under Elective I the student Shall study LATEX for 1 credit.

**504306**

**Lab Practice I**

**Teaching Scheme:**

**Practical 4 Hrs/ Week**

**Examination Scheme:**

**Term Work : 50 Marks**

**Oral/ Presentation: 50 Marks**

**Credits :4**

**Lab Practice I:**

The laboratory work will be based on completion of minimum two assignments/experiments confined to the courses of the semester.

# **SEMESTER-II**



**504307**

## **Computational Electromagnetics**

**Teaching Scheme:**  
**Lectures 4 Hrs/ Week**

**Examination Scheme:**  
**Theory :**  
**50 Marks (In Semester)**  
**50 Marks (End**  
**Semester)**  
**Credits : 4**

### **Course Outcomes:**

Students who successfully complete the course will be able to:

- Identify conventional and state-of-the-art computational electromagnetic techniques for modeling wireless communication devices, high speed electronic circuits, millimeter-wave ICs and antenna populations.
- Apply electromagnetic wave theories and tools for the applications of wave propagation, radiation, scattering, and in particular, wireless communications.
- Understand systematic numerical techniques and software packages for solving generalized practical electromagnetic problems.

### **Module I**

**( 8Hrs )**

#### **Introduction to Computational Electromagnetics**

Classification of Electromagnetic Problems, Classification of methods of analysis, mathematical frame work, Overview of Computational methods. Analytical methods and Orthogonal functions, Green's Function, Green function for two dimensions and for bounded regions.

#### **Finite Difference Methods**

Finite Difference Approximations , Treatment of Interface and Boundary Conditions, Finite Difference Analysis of Guiding Structures.

### **Module II**

**( 8Hrs )**

#### **Finite Difference Time Domain Analysis**

Pulse Propagation in a Transmission Line, FDTD Analysis in One-Dimension, Applications of One-Dimensional FDTD Analysis, FDTD Analysis in Two-Dimensions, FDTD Analysis in Three-Dimensions, Implementation of Boundary Conditions in FDTD, Advances in FDTD.

### **Module III**

**( 8Hrs )**

#### **Variational Methods**

Calculus of Variations, Stationary Functional and Euler Equations, The Ritz Variational Method, Applications of Ritz Approach, Construction of Functional from PDE, Method of Weighted Residuals

## **Module IV**

( 10Hrs )

### **Finite Element Methods**

Basic Steps in finite element analysis, FEM analysis in one dimension, FEM analysis in two-dimension.

### **Method of Moments**

Point Matching and Galerkin's Methods, Eigenvalue Analysis using MoM, Solution of Integral Equations using MoM , Fast Multipole Solution Methods for MoM , Comparison of FDM, FDTD, FEM and MoM, Hybrid Computational Methods

### **References:**

1. Ramesh Garg, Analytical and Computational methods in Electromagnetics, Artech House, INC, 2008
2. Mathew N O Sadiku, Numerical Techniques in Electromagnetics with MATLAB, Third Edition, CRC Press, Taylor and Francis Group, 2009

## **Computational Electromagnetics**

### **Laboratory Assignments/Experiments:**

1. Write an assignment on classification, applications, merits and demerits of all the computational electromagnetic method.
2. Write survey paper on various commercial CEM software available.
3. Carry out the analysis of a given structure using FDTD.
4. Carry out the analysis of a given structure using MoM.
5. Carry out the analysis of a given structure using FEM.

**504308**

**RF and MMIC Technology**

**Teaching Scheme:**  
**Lectures 4 Hrs/ Week**

**Examination Scheme:**  
**Theory :**  
**50 Marks (In Semester)**  
**50 Marks (End**  
**Semester)**  
**Credits : 4**

**Course Objectives:**

- 1) To understand, Study and analysis of MMIC Technology.
- 2) To understand and study of Fabrication of MMIC Technology.
- 3) To understand and study of Synthesis Techniques of Linear and non Linear MMIC.
- 4) To understand and study of CAD Techniques for MMIC Design.
- 5) To understand and study of MMIC Measurement Techniques.
- 6) To understand and study of different applications of MMIC Technology.

**Course Outcomes:**

Upon completion of the course, students will be able to:

1. Determine and use parameters of MMIC Technology.
2. Determine and study of Fabrication of MMIC Technology.
3. Perform analysis, Study of Synthesis Techniques for design of Linear and non Linear MMIC.
4. Study and Understand CAD Techniques for MMIC Design.
5. Study and understand different MMIC Measurement Techniques.
6. Study and understand different applications of MMIC Technology.

**Module I**

**( 8 Hrs )**

**MMIC Technology**

Advantages, disadvantages, cost, performance, size and mass, reproducibility, reliability, applications, active device technology, design approach, multi-chip module technology.

**Fabrication Technology**

HEMT, HBT, BJT, FET, Resistors, capacitors, spiral inductors, via-holes and grounding, Microstrip couplers and splitters, Multi-layer techniques, thin film and multi-layer directional couplers and baluns.

**Module II**

**( 10Hrs )**

**Synthesis Techniques**

Synthesis of linear and non linear MMIC, Matrix representation, network matrix decomposition, synthesis on n-port on the base of elementary two port, time domain method, method of harmonic balance, volterra series, describing function methods.

### **Module III**

( 8Hrs )

#### **CAD Techniques**

Integrated CAD design environment, CAD package feature, circuit simulation engine, commercial CAD packages like AWR microwave office, Cadence analog artist etc.

#### **MMIC Design**

Digital modulators, switches, phase shifters, multipliers and up-converters.

### **Module IV**

( 8Hrs )

#### **MMIC Measurement**

Device and circuit measurement techniques, measurement in MMIC media, MMIC test system, System applications of MMICs: Radio system, satellite communication, Broadcast system, Future trend in MMICs

### **References:**

1. D.Robertson and S.Lucyszyn „RFIC and MMIC design technology“
2. L.G.Maloratsky „Passive RF and microwave integrated circuits“. Elsevier 3)  
Ivan Kneppo, Kluwer, “Microwave Integrated Circuits”.

## **RF and MMIC Technology**

### **Laboratory Assignments/Experiments:**

1. To test and verify Microwave Integrated Circuits using Microstrip trainer kit and plot the results.
2. Using suitable software design, simulate and fabricate any one of the following mentioned MIC.
  - a. Band pass filter (2.5 to 2.8 GHz)
  - b. Band stop filter (2.5 to 2.8 GHz)
  - c. Branch line coupler,
  - d. Rat race hybrid coupler
3. Design an amplifier at 5GHz with S parameters as follows implement and simulate in suitable CEM software.

$$S_{11} \quad 0.73 \angle 176^{\circ}, S_{21} \quad 3.32 \angle 75^{\circ}$$

$$S_{12} \quad 0.05 \angle 34^{\circ}, S_{22} \quad 0.26 \angle 107^{\circ}$$

4. Check for amplifier stability and plot stability graph.(using suitable CEM software )  
Case Study of various numerical electromagnetic software's available.

**504309**

## **Wireless Communications System**

**Teaching Scheme:**  
**Lectures 4 Hrs/ Week**

**Examination Scheme:**  
**Theory :**  
**50 Marks (In Semester)**  
**50 Marks (End**  
**Semester)**  
**Credits : 4**

### **Module I ( 10Hrs )**

#### **Overview of Wireless systems**

Evolution of wireless communications systems from 1G to 4G, various wireless standards, tele-traffic engineering, Traffic measurement units, Traffic distribution, Grade of service, Blocking probability, Erlang Distribution, Poisson's model, queuing theory.

#### **Cellular Communications**

Cell concept, Hexagonal geometry, co-channel interference ratio and its reduction, cell splitting, adjacent channel interference, multiple access techniques, spectral efficiency, hand off mechanisms.

### **Module II ( 8Hrs )**

#### **Propagation Characteristics of Mobile Channel**

Free-space attenuation, Attenuation over reflecting surface, Effect of earth's curvature, Radio wave propagation, Characteristics of wireless channel, Multipath delay spread, Coherence bandwidth, and coherence time, Signal fading statistics, Level crossing rate and average fade duration, Propagation path-loss models, Indoor loss models, Fade margin, Link margin.

### **Module III ( 10Hrs )**

#### **The GSM System and General Packet Radio Service (GPRS)**

GSM features, System architecture, logical channels, GSM frame and Slot structures, Data services in GSM.

#### **CDMA Technology**

Direct Spread CDMA principles, Capacity of CDMA, Transmitter and Receivers, System features, system architecture, spectrum allocation.

### **Module IV ( 8Hrs )**

#### **Universal Mobile Telecommunications System (UMTS)**

System features, Wireless network architecture, Physical layer, MAC layer protocol, Radio Link control protocol, PDCP, BMC protocol, Radio resource control protocol, Beyond 3G.

**References:**

1. M.R Karim, Mohsen Sarraf, W-CDMA and cdma2000 for 3G Mobile Networks, McGraw-Hill, 2002
2. Vijay K Garg, Wireless Communications and Networking, Morgan Kaufmann Publishers, Elsevier Inc.,2007
3. William C.Y.Lee, "Mobile Cellular Telecommunications, Second Edition, Tata McGraw-Hill Edition
4. T.S. Rappaport, "Wireless Communications Principles And Practice", Pearson Education
5. Vijay Garg and Joseph Wilkes, "Principles And Applications Of GSM", Pearson Education

**Wireless Communications System****Laboratory Assignments/Experiments:**

1. Simulate BPSK-DSSS model (on Simulink/MATLAB)
2. Simulate FHSS (on Simulink/MATLAB)
3. Simulate RAKE receiver model (on Simulink/MATLAB)
4. Simulate 4-, 16- & 64-QAM (on Simulink/MATLAB)
5. GMSK modulation technique for GSM (Hardware or Simulation)
6. Receiver using Viterbi algorithm for GSM
7. BER using Viterbi algorithm for GSM
8. Study of GSM and CDMA set up

**504310**

**Elective-II: Microstrip Antennas**

**Teaching Scheme:**

Lectures 4 Hrs/Week

**Examination Scheme:**

In Semester: 50 Marks

End Semester: 50 Marks

**Credits:4**

**Course Objectives:**

- i. Students will be introduced to Microstrip antennas, their principle of operation, analysis and their applications.
- ii. Students will be introduced to different analytical models of Microstrip antennas including transmission model, cavity model, full wave analysis, FDTD etc.
- iii. To lay a background on various types of Microstrip antennas including Fractal Antennas, Reconfigurable antennas, Rectangular Microstrip patch antenna and circular Microstrip patch antennas.

**Course Outcomes:**

Upon successful completion of this course, students should be able to:

1. Identify, analyze and interpret the fundamental parameters of Microstrip antennas.
2. Formulate the analytical model and radiation fields of Microstrip antenna, at both near- and far zone.
3. Formulate and analyze the radiation from Fractal and reconfigurable antenna.
4. Formulate and analyze rectangular and circular microstrip patch antennas.
5. Ability to design and conduct experiments, gather data, analyze and interpret results for investigating Microstrip antenna engineering problems.

**Module I**

**( 8Hrs )**

**Introduction to Microstrip Antennas**

Characteristics of MSAs, Feeding techniques, Methods of analysis, Radiation fields, Surface Waves, Various Micro strip Configurations, Applications.

**Module II**

**( 10Hrs )**

**Analytical Models for MSAs**

Transmission line models, cavity model, Generalized cavity model, Multiport Network model, Radiation fields, Aperture Admittance, Mutual Admittance, Model for coaxial probe in MSA, comparison of Analytical Models, Full wave analysis of Micro strip Antennas, Special domain Full wave analysis, Mixed potential Integral Equation Analysis, FDTD analysis.

**Module III**

**( 8Hrs )**

**Rectangular Micro strip Antennas**

Models for Rectangular MSA, Design considerations for rectangular MSA, Tolerance Analysis, Mechanical tuning, Quarter wave Rectangular patch antennas,

**Circular MSAs**

Analysis, design considerations, comparison of Circular MSAs with Rectangular MSAs.



## **Module IV**

( 8Hrs )

### **Fractal Antennas**

Introduction to Fractal antennas, different types of fractal geometries, applications

### **Reconfigurable Antennas**

Introduction to Reconfigurable antennas, Various types reconfigurable antennas: frequency, pattern, and polarization reconfigurable antennas, methods for achieving various reconfigurability, Various switching elements: PIN diode, MEMS, mechanical relays.

### **References:**

1. Ramesh Garg, PrakashBhartia, InderBahl, ApisakIttipiboon, Micro strip Antenna Design Handbook, Artech House, 2001
2. Girish Kumar, K.P. Ray, Broadband Microstrip Antennas, Artech House, Inc, 2003
3. John Gianvittorio, Fractal Antenna Design, Characterization, and Applications, University of California, Los Angeles, 2000
4. Jennifer T Bernhard, Reconfigurable Antennas, Morgan &Clayopol Publishers, 2007

### **Microstrip Antennas**

**Laboratory Assignments/Experiments:(at least two experiments from the list to be executed)**

1. Design, simulate, fabricate and test the rectangular microstrip.
2. Design, simulate, fabricate and test the circular microstrip.
3. Design, simulate, fabricate and test the array of rectangular microstrip.
4. Simulate, fabricate and test the fractal antenna.  
Simulate, fabricate and test the reconfigurable.

**504310**

**Elective II: Smart Antennas**

**Teaching Scheme:**

Lectures: 4 Hrs/Week

**Examination Scheme:**

In Semester: 50 Marks

End Semester: 50 Marks

**Credits:4**

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**Course Objectives:**

- Applicants will be familiar with the Smart Antenna Systems and what are the benefits of smart antenna technology.

**Course Outcomes:**

- understand Types of Smart Antenna Systems know the Spatial Signature Definition
- know the Adaptive Algorithm Classification
- know Direction of Arrival Estimation
- know the Benefits of Smart Antenna

**Module I**

**(8Hrs)**

**Introduction to Smart Antennas**

Spatial Processing for Wireless Systems, Key Benefits of Smart Antenna Technology, Introduction to Smart Antenna Technology, the Vector Channel Impulse Response and the, Spatial Signature, Spatial Processing Receivers , Fixed Beam forming Networks , Switched Beam Systems.

**Module II**

**(10Hrs)**

**Adaptive Antenna Systems**

Adaptive Antenna System, Adaptive Beam forming, Wideband Smart Antennas Spatial Diversity, Diversity Combining, and Sectoring, Digital Radio Receiver Techniques and Software Radios for Smart Antennas, Transmission Beam forming.

**Smart Antennas Techniques for CDMA**

Non-Coherent CDMA Spatial Processors, Coherent CDMA Spatial Processors and the Spatial, Processing Rake Receiver , Multi-User Spatial Processing , Dynamic Re-sectoring Using Smart Antennas , Downlink Beam forming for CDMA.

**Module III**

**(8Hrs)**

**CDMA System Range and Capacity Improvement Using Spatial Filtering**

Range Extension In CDMA, Single Cell Systems with Spatial Filtering at the Base Station Reverse Channel Performance of Multi-cell Systems with Spatial Filtering at the Base Station Reverse Channel Spatial Filtering at the WLL Subscriber Unit, Range and Capacity Analysis Using Smart Antennas - A Vector-Based Approach.

**Module IV**

**(10Hrs)**

**Optimal Spatial Filtering and Adaptive Algorithms**

Impact of Multipath on Optimal Spatial Filtering , Performance of Underloaded and Overloaded Adaptive Arrays , Adaptive Algorithms , Adaptive Algorithms for CDMA, Multitarget Decision-Directed Algorithm (MT-DD), Least Squares De-spread Re-spread Multitarget Array (LS-DRMTA) , Least Squares De-spread Re-spread Multitarget Constant Modulus Algorithm.

### **References:**

1. T.S. Rappaport and J.C. Liberti, Smart Antennas for Wireless Communications, Prentice Hall, NJ: Prentice Hall,1999
2. T.S. Rappaport, Smart Antennas: Adaptive Arrays, Algorithms, & Wireless Position Location, New York: Prentice-Hall,1998
3. R.T. Compton Jr., Adaptive Arrays – Concepts and Performance, Englewood, NJ: Prentice Hall, 1998

### **Smart Antennas**

#### **Laboratory Assignments/Experiments:**

1. Simulate the adaptive array and plot its radiation pattern in MATLAB with MMSE approach.
2. Simulate the adaptive array and plot its radiation pattern in MATLAB with Applebaum approach.
3. Simulate switched beam antenna array using Butler matrix on suitable Computational electromagnetic software, fabricate and test.
4. Implement the smart antenna system with various algorithms.
5. MATLAB simulation of smart antenna system and various algorithms.



**504310**

**Elective II: Cognitive Radio**

**Teaching Scheme:**

Lectures: 4 Hrs/Week

**Examination Scheme:**

Theory: In Semester: 50 Marks

End Semester: 50 Marks

**Credits:4**

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**Course Objectives**

The Objectives of this course are to:-

- Describe architecture and requirements of Cognitive Radio for end to end communication.
- Categorize different elements of Software Communication Architecture.
- Design the implementation of algorithms of smart antennas for cognitive radio.

**Course Outcomes**

Having successfully completed this course, students will be able to:

1. Describe the architecture of Cognitive Radio for end-to-end communication.
2. Develop algorithms of SCA to test different radio sets.
3. Develop smart antenna algorithms.

**Module I**

**(12Hrs)**

**Software Defined Radio**

Software Defined Radio Architecture , Digital Signal Processor and SDR Baseband Architecture  
Reconfigurable Wireless Communication Systems , Unified Communication Algorithm,  
Reconfigurable OFDM Implementation , Reconfigurable OFDM and CDMA , Digital Radio  
Processing , Conventional RF , Digital Radio Processing (DRP) Based System Architecture.

**Cognitive Radio Communications**

Cognitive Radios and Dynamic Spectrum Access , the Capability of Cognitive Radios  
Spectrum Sharing Models of DSA, Opportunistic Spectrum Access: Basic Components  
Networking the Cognitive Radios, Analytical Approach and Algorithms for Dynamic Spectrum  
Access , Dynamic Spectrum Access in Open Spectrum , Opportunistic Spectrum Access ,  
Opportunistic Power Control, Fundamental Limits of Cognitive Radios

**Module II**

**(10Hrs)**

**Cognitive Radio Networks**

Network Coding for Cognitive Radio Relay Networks , System Model , Network Capacity  
Analysis on Fundamental CRRN Topologies , Link Allocation , Numerical Results , Cognitive  
Radio Networks Architecture, Network Architecture , IP Mobility Management in CRN,  
Terminal Architecture of CRN , Cognitive Radio Device Architecture , Re-configurable MAC,  
Radio Access Network Selection , QoS Provisional Diversity Radio Access Networks,  
Cooperative/Collaborative Diversity and Efficient Protocols , Statistical QoS Guarantees over  
Wireless Asymmetry, Collaborative Relay Networks , Scaling Laws of Ad-hoc and Cognitive

Radio Networks , Network and Channel Models , Ad-hoc Networks , Cognitive Radio Networks .

### **Module III**

(8Hrs)

#### **Spectrum Sensing**

Spectrum Sensing to Detect Specific Primary System , Conventional Spectrum Sensing , Power Control , Power-Scaling Power Control , Cooperative Spectrum Sensing , Spectrum Sensing for Cognitive OFDMA Systems , Cognitive Cycle , Discrimination of States of the Primary System , Spectrum Sensing Procedure , Spectrum Sensing for Cognitive Multi-Radio Networks, Multiple System Sensing , Radio Resource Sensing .

### **Module IV**

( 10Hrs )

#### **Medium Access Control**

MAC for Cognitive Radios , Multichannel MAC , General Description of Multichannel MAC , Multichannel MAC: Collision Avoidance/Resolution, Multichannel MAC: Access Negotiation , Slotted-ALOHA with Rate-Distance Adaptability, System Model , CSMA with AMC , Carrier Sense Multiple Access with Spatial-Reuse, Transmissions , Analysis of CSMA-ST , A Cross-Layer Power-Rate Control Scheme.

#### **References:**

1. Kwang-Cheng Chen and Ramjee Prasad *Cognitive Radio Networks* , John Wiley & Sons Ltd.,2009
2. HüseyinArslan , *Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems* Published by Springer 2007

#### **Cognitive Radio**

##### **Laboratory Assignments/Experiments:**

1. To study and simulate OFDM Transmitter and Receiver using Matlab/ Simulink.
  2. To simulate spectrum sensing using matched filter detection using Matlab.
  3. To simulate spectrum sensing using energy detection using Matlab.
  4. To Implement cognitive radio using test beds Like USRP.
- To simulate cognitive radio environment using Matlab OR Suitable Network Simulators.

**504310**

**Elective II: Remote Sensing and Satellite Image Processing**

**Teaching Scheme:**

Lectures: 4 Hrs/Week

**Examination Scheme:**

In Semester: 50 Marks

End Semester: 50 Marks

**Credits:4**

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**Course Outcomes:**

On completion of the course, the students shall have acquired the following knowledge and understanding:

- the basic physical principles of remote sensing,
- the basic technical principles of satellites, sensors and ground segments in data collection and the properties of the available data from these systems,
- the principles of digital image processing and manipulation in remote sensing,
- important applications for satellite remote sensing in research and the public and private sectors, and the ability to give examples of and suggest uses for remote sensing in different climate zones.

**Module I**

**(8Hrs )**

**Introduction to Remote sensing**

Remote sensing :Basic principles and introduction ,stages in remote sensing data acquisition, Physics of electromagnetic spectrum, nature of radiation and spectrum, Understanding energy sources and characteristics of Electromagnetic Radiation, atmospheric interactions with EMR such as radiance, reflectance, transmission, emission, spectral reflectance curves.

**Module II**

**Remote sensing platform and sensors**

**(10Hrs)**

Sensor parameters:Radiometric,spectral and spatial resolution, Image sensor systems, Microwave image systems, Multispectral image sensor system, Thermal image sensing system, Study of earth resource satellites, Meteorological satellites, satellites carrying Microwave sensors, Quick bird, Cartosat-1, Microwave remote sensing, principle, SAR, SLAR and LIDAR, Multispectral image sensing ,Hyper spectral thermal sensing and imaging, Landsat and ASTER.

**Module III**

**(8Hrs)**

**Remote sensing Models and Image Processing**

Data Models, Preprocessing, Geometric, radiometric and atmospheric correction methods, Image registration, spatial transforms ,image model for spatial filtering, linear filters, statistical filter and gradient filters, filtering with Fourier Transform, contrast enhancement .

**Module IV**

**(8Hrs)**

**Image Processing and Analysis**

Spectral transforms, Multispectral ratio, PCA transformation, Image Classification, supervised and unsupervised, Non Parametric and Parametric classification, spatial spectral segmentation, Fuzzy set classification, Hyper spectral image analysis

**References:**

1. Remote Sensing: Models and Methods for Image Processing, Robert A. Schowengerdt, Third Edition, Academic Press, 2007.
2. Remote Sensing and Image Interpretation, Thomas M Lillesand, Ralph W Kiefer, Jonathan w Chipman, Wiley.
3. Remote Sensing and Geographical Information Systems, M.Anji Reddy, BS Publications.
4. Remote sensing: Principles and Interpretations, Floyd F Sabins.



**504310**

**Elective II: \*Software Tools**

**Teaching Scheme:**

Lectures: 1 Hrs/Week

**Examination Scheme:**

**Credits:1**

**Course Objectives:**

The objectives of this course are to :

- Design applications using open source software.

**Course Outcomes:**

On completion of the course, student will be able to

- Develop applications using open source software.

Introduction to software tools such as Octave, MATLAB, LAB VIEW, RTLinux, VxWorks,  $\mu$ COS-II, Tiny OS, ANDROID, Xilinx, Microwind, Tanner, TCAD Tools, NS-II, NS-III, OMNET++, OPNET, AWR Microwave office, CAD Feko, IE-3D.

\*For each Subject under Elective II the student Shall study open source/evaluation versions of at least two software tools mentioned above and should present term paper.

**504311**

**Lab Practice II**

**Teaching Scheme:**  
**Practical 4 Hrs/ Week**

**Examination Scheme:**  
**Term Work : 50 Marks**  
**Oral/ Presentation: 50 Marks**  
**Credits : 4**

**Lab Practice II:**

The laboratory work will be based on completion of minimum two assignments/experiments from each course of the semester.

**504312**

**Seminar I**

**Teaching Scheme:**

**4 Hrs/Week**

**Examination Scheme:**

**Term Work : 50 Marks**

**Oral/ Presentation: 50 Marks**

**Credits:4**

**Seminar I:** shall be on the topic relevant to latest trends in the field of concerned branch, preferably on the topic of specialization based on the electives selected by him/her approved by authority. The student shall submit the seminar report in standard format, duly certified for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

**SECOND YEAR  
SEMESTER I**

**604301**

## **EMI and EMC Techniques**

**Teaching Scheme:**

Lectures: 4 Hrs/Week

**Examination Scheme:**

In Semester: 50 Marks

End Semester: 50 Marks

**Credits:4**

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### **Course Objectives:**

- To introduce the concepts of electromagnetic interference and electromagnetic compatibility
- To study the electromagnetic interference control techniques
- To learn electromagnetic compatibility issues with regard to the design of PCBS

### **Course Outcomes:**

- The students would gain enough knowledge to understand the concept of EMI / EMC related to product design & development.
- Students shall be able to analyze the different EM coupling principles and its impact on performance of electronic system
- Students would know how to bring down the electromagnetic interference highlighting the concepts of both susceptibility and immunity
- The students will be able to analyze various EM compatibility issues with regard to the design of PCBs and ways to improve the overall system performance.

### **Module I**

**(8Hrs)**

#### **Sources and effects of EMI**

Intersystem and intra system: EMI predictions and modelling; Cross talk: cable wiring and coupling: shielding and shielding materials. Grounding and bounding

### **Module II**

**(12Hrs)**

#### **Transmitter and Receiver Models for EMI Predictions**

Types of emissions: Amplitude culling Frequency culling. Detail prediction and Performance prediction of various emissions. Receiver EMI functions. Receiver models for amplitude culling, frequency culling, Detail predictions and performance prediction

#### **Antenna and Propagation Models for EMI Prediction**

Antenna EMI prediction considerations, Antenna models for amplitude culling, frequency culling and detail prediction. Propagation considerations, Propagation models for amplitude culling, Propagation models and detail prediction

### **Module III**

**(8Hrs)**

#### **EMI measurements**

Open area test site measurements. Measurement precautions: Radiated and Conducted interference measurements; control requirements and test methods.

### **Module IV**

**(10Hrs )**

## **Grounding, Shielding, and Bonding**

Shielding and shielding materials, Grounding and bonding techniques.

## **EMI Filters and Standards**

EMI filters characteristics of LPF, HPF, BPF and BEF, EMI standards-Military and industrial standards. FCC regulations.

## **References:**

1. Prasad Kodali V., Engineering Electromagnetic Compatibility, IEEE press, 1996
2. David A Weston, Electromagnetic Compatibility: Principles and Applications, Marcel Decer, 2001
3. Kaiser BE., Principles of Electromagnetic Compatibility, 3<sup>rd</sup> edition, Norwood MA: Artech House, 1987

## **EMI and EMC Techniques (Optional)**

### **Laboratory Assignments/Experiments:**

1. Insertion loss
2. EMI filters (LPF, HPF, BPF)
  - a. Common mode filter
  - b. Differential Mode filter
3. Shielding Effect
4. Radiated emission Conducted emission

**604302**

## **Radar and Satellite Communication**

**Teaching Scheme:**

Lectures: 4 Hrs/Week

**Examination Scheme:**

Theory: In Semester: 50 Marks

End Semester: 50 Marks

**Credits:4**

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### **Course Objective**

To provide good understanding of radar systems, radar signal processing, radar target tracking and electronic navigational systems.

### **Course Outcomes:**

At the end of the course the student must be able to

- Understand radar Systems
- Analyze radar Systems
- Analyze radar signal processing
- Appreciate the wide range of applications of radar Systems
- Understand Target detection and tracking using radar systems
- Understand satellite and its subsystems
- Understand multiple Access techniques.

### **Module I**

**(8Hrs )**

#### **Fundamentals of Radar**

Radar equation and Radar Cross Section. Methods for RCS Estimation: GO, PO, GTD and PTD techniques. Ray tracing.RCS of simple and complex targets. Pulse radar, CW radar, blocks, design of blocks, Display methods and numerical based on this topic.

### **Module II**

**(10Hrs)**

#### **Fundamentals of surveillance Radar**

Radar design, PRF, unambiguous range and velocity, pulse length, sampling, clutters. Tracking and search radar, antenna beam shapes required, Radar guidance, frequency agility.

#### **Tracking Radar and Pulse Radar**

Real array Imaging radars.Synthetic array, Radars. Signal processing methods, Applications of radar in remote sensing, Geological survey, weather prediction

### **Module III**

**(8Hrs)**

#### **Introduction To Satellite Systems**

Orbital mechanism and launching of artificial satellite, types of satellite as per altitude, Kepler's law, equations, satellite orbit, look angle calculation, orbital perturbation.

#### **Satellite Subsystems**

AOCS, TTC & M, power requirement, satellite antenna. Satellite link design.

#### **Module IV**

**(8Hrs)**

#### **Multiple Access Techniques**

Multiple access techniques FDMA, TDMA, SS-TDMA; Interference in FDMA systems. Power budget analysis, Applications and recent trends in satellite systems.

#### **References:**

1. S.Kingslay,S.Quegan , Understanding of Radar TMH 1993.
2. Radar Handbook, by Merrill Skolnik
3. Radar system principle by H.R.Raemer CRC press.
4. Satellite communication by T Pratt,C.Bostian and J.Allnutt.Wiley.
5. Satellite communication by D.RoddyMcgrawhill.

#### **Radar and Satellite Communication (Optional)**

#### **Laboratory Assignments/Experiments:**

1. Simulate satellite transponder.
2. Simulate low power satellite link using suitable software.
3. Simulate RADAR system using suitable software.
4. Calculate RCS of sphere, cone of a given object.

Simulate different modulation schemes used in satellite system.



### List of Elective-III subjects

Select one subjects from Group-I, and one subject from Group-II from the following list as Elective-III.

Group		Subject	Credit
I	1	Value Education, Human Rights and Legislative Procedures	3
	2	Environmental Studies	3
	3	Renewable Energy Studies	3
	4	Disaster Management	3
	5	Knowledge Management	3
	6	Foreign Language	3
	7	Economics for Engineers	3
	8	Engineering Risk – Benefit Analysis	3
II	1	Optimization Techniques	2
	2	Fuzzy Mathematics	2
	3	Design and Analysis of Algorithms	2
	4	CUDA	2

**604103**

**ELECTIVE III Group I:  
Value Education, Human Rights and Legislative Procedures**

**Teaching Scheme:**

Lectures: 3 Hrs/Week

**Examination Scheme:**

Theory: In Semester: 50 Marks

End Semester: 50 Marks

**Credits:3**

**Module I**

Values and Self Development-Social values and individual attitudes, Work ethics, Indian vision of humanism, Moral and non moral valuation, Standards and principles, Value judgments. Importance of cultivation of values, Sense of duty, Devotion, Self reliance, Confidence, Concentration, Truthfulness, Cleanliness, Honesty, Humanity, Power of faith, National unity, Patriotism, Love for nature, Discipline.

**Module II**

Personality and Behavior Development- Soul and scientific attitude, God and scientific attitude, Positive thinking, Integrity and discipline, Punctuality, Love and kindness, Avoiding fault finding, Free from anger, Dignity of labor, Universal brotherhood and religious tolerance, True friendship, Happiness vs. suffering love for truth, Aware of self destructive habits, Association and cooperation, Doing best, Saving nature.

**Module III**

Human Rights- Jurisprudence of human rights nature and definition, Universal protection of human rights, Regional protection of human rights, National level protection of human rights, Human rights and vulnerable groups.

Legislative Procedures- Indian constitution, Philosophy, fundamental rights and duties, Legislature, Executive and Judiciary, Constitution and function of parliament, Composition of council of states and house of people, Speaker, Passing of bills, Vigilance, Lokpal and functionaries

**References:**

1. y, S.K., Values and Ethics for Organizations Theory and Practice, Oxford University Press, New Delhi, 2001.
2. Kapoor, S.K., Human rights under International Law and Indian Law, Prentice Hall of India, New Delhi, 2002.
3. Basu, D.D., Indian Constitution, Oxford University Press, New Delhi, 2002.
4. Frankena, W.K., Ethics, Prentice Hall of India, New Delhi, 1990
5. Meron Theodor, Human Rights and International Law Legal Policy Issues, Vol. 1 and 2, Oxford University Press, New Delhi, 2000

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**Elective III, Group I:  
Environmental Studies**

**Teaching Scheme:**

Lectures: 3 Hrs/Week

**Examination Scheme:**

Theory: In Semester: 50 Marks

End Semester: 50 Marks

**Credits:3**

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**Course Objective:**

1. To provide an in-depth introduction to Natural Resources and Ecosystems.
2. To impart knowledge regarding Environmental Pollution and disaster management.
3. Understand Social issues related with Environment.
4. To get fundamental knowledge of Environment protection act, Wildlife protection act, Environmental issues in legislation.
5. Understand Role of information technology in environment and human health.

**Course Outcomes:**

1. Describe Renewable and nonrenewal energy resources and various associated problems.
2. Get overview of Ecosystems: Concept, Structure and function.
3. Describe Causes, effects and control of environmental pollution
4. Get motivation for Water conservation and watershed management.
5. Learn importance of various Environment protection act.

**Module I**

Introduction and Natural Resources: Multidisciplinary nature and public awareness, Renewable and nonrenewal resources and associated problems, Forest resources, Water resources, Mineral resources, Food resources, Energy resources, Land resources, Conservation of natural resources and human role.

Ecosystems: Concept, Structure and function, Producers composers and decomposers, Energy flow, Ecological succession, Food chains webs and ecological pyramids, Characteristics structures and functions of ecosystems such as Forest, Grassland, Desert, Aquatic ecosystems.

**Module II**

Environmental Pollution- Definition, Causes, effects and control of air pollution, water pollution, soil pollution, marine pollution, noise pollution, thermal pollution, nuclear hazards, human role in prevention of pollution, Solid waste management, Disaster management, floods, earthquake, cyclone and landslides.

**Module III:**

Social issues and Environment- Unsustainable to sustainable development, Urban problems related to energy, Water conservation and watershed management, Resettlement and re-habitation, Ethics, Climate change, Global warming, Acid rain, Ozone layer depletion, Nuclear accidents, holocaust, Waste land reclamation, Consumerism and waste products, Environment protection act, Wildlife protection act, Forest conservation act, Environmental issues in legislation, population explosion

and family welfare program, Environment and human health, HIV, Women and child welfare, Role of information technology in environment and human health.

**References:**

1. Agarwal, K.C., Environmental Biology, Nidi Publication Ltd., Bikaner, 2001.
2. BharuchaErach, Biodiversity of India, Mapin Publishing Pvt. Ltd., Ahmadabad, 2002.
3. Bukhootsow, B., Energy Policy and Planning, Prentice Hall of India, New Delhi, 2003.
4. Cunningham, W.P., et al. , Environmental Encyclopedia, Jaico Publishing House, Mumbai, 2003.

**604103**

**Elective III, Group I:  
Renewable Energy Studies**

**Teaching Scheme:**

Lectures: 3 Hrs/Week

**Examination Scheme:**

Theory: In Semester: 50 Marks

End Semester: 50 Marks

**Credits:3**

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**Module I : Solar Energy :**

**(8 Hrs.)**

Photovoltaic Systems: Introduction to the Major Photovoltaic System Types, Current–Voltage Curves for Loads, Grid-Connected Systems: Interfacing with the Utility, DC and AC Rated Power, The “Peak-Hours” Approach to Estimating PV Performance, Capacity Factors for PV Grid Connected Systems, PV Powered Water Pumping, PV systems – off grid systems and scope for inclusive growth of rural India.

**Module II :Wind Energy :**

**(8 Hrs.)**

Wind Energy: wind speed and power relation, power extracted from wind, wind distribution and wind speed predictions. Wind power systems: system components, Types of Turbine, Choice of generators, electrical load matching, power control, Effect of wind speed variations, tower height and its effect, Variable speed operation, maximum power operation, control systems, Design consideration of wind farms and control

**Module III :Other Energy Sources :**

**(8 Hrs.)**

Biomass – various resources, energy contents, technological advancements, conversion of biomass in other form of energy – solid, liquid and gases. Gasifiers, Biomass fired boilers, Co-firing, Generation from municipal solid waste, Issues in harnessing these sources. Mini and micro hydel plants scheme layout economics. Tidal and wave energy, Geothermal and Ocean-thermal energy conversion (OTEC) systems – schemes, feasibility and viability. Fuel cell- types and operating characteristics, efficiency, energy output of fuel cell

**References**

1. Renewable energy technologies - R. Ramesh, Narosa Publication.
2. Energy Technology – S. Rao, Parulkar
3. Non-conventional Energy Systems – Mittal, Wheelers Publication.
4. Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”,CRC Press
5. Renewable Energy Technologies – Chetan Singh Solanki, PHI Learning Pvt. Ltd.

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**Elective III, Group I:  
Disaster Management**

**Teaching Scheme:**

Lectures: 3 Hrs/Week

**Examination Scheme:**

Theory: In Semester: 50 Marks  
End Semester: 50 Marks

**Credits:3**

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**Module I**

Introduction :Concepts and definitions: disaster, hazard, vulnerability, risk, capacity, impact, prevention, mitigation). Disasters classification; natural disasters (floods, draught, cyclones, volcanoes, earthquakes, tsunami, landslides, coastal erosion, soil erosion, forest fires etc.); manmade disasters (industrial pollution, artificial flooding in urban areas, nuclear radiation, chemical spills etc); hazard and vulnerability profile of India, mountain and coastal areas, ecological fragility

**Module II**

Disaster Impacts :Disaster impacts (environmental, physical, social, ecological, economical, political, etc.); health, psycho-social issues; demographic aspects (gender, age, special needs); hazard locations; global and national disaster trends; climate-change and urban disasters.

**Module III**

Disaster Risk Reduction (DRR) : Disaster management cycle – its phases; prevention, mitigation, preparedness, relief and recovery; structural and non-structural measures; risk analysis, vulnerability and capacity assessment; early warning systems, Post-disaster environmental response (water, sanitation, food safety, waste management, disease control); Roles and responsibilities of government, community, local institutions, NGOs and other stakeholders; Policies and legislation for disaster risk reduction, DRR programmes in India and the activities of National Disaster Management Authority.

**References:**

1. <http://ndma.gov.in/> (Home page of National Disaster Management Authority).
2. <http://www.ndmindia.nic.in/> (National Disaster management in India, Ministry of Home Affairs).
3. PradeepSahni, 2004, Disaster Risk Reduction in South Asia, Prentice Hall.
4. Singh B.K., 2008, Handbook of Disaster Management: techniques & Guidelines Rajat Publication.
5. Ghosh G.K., 2006, Disaster Management ,APH Publishing Corporation.

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**Elective III, Group I:  
Knowledge Management**

**Teaching Scheme:**

Lectures: 3 Hrs/Week

**Examination Scheme:**

Theory: In Semester: 50 Marks

End Semester: 50 Marks

**Credits:3**

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**Module I**

Introduction: Definition, evolution, need, drivers, scope, approaches in Organizations, strategies in organizations, components and functions, understanding knowledge; Learning organization: five components of learning organization, knowledge sources, and documentation. Essentials of Knowledge Management; knowledge creation process, knowledge management techniques, systems and tools.

**Module II**

Organizational knowledge management; architecture and implementation strategies, building the knowledge corporation and implementing knowledge management in organization. Knowledge management system life cycle, managing knowledge workers, knowledge audit, and knowledge management practices in organizations, few case studies

**Module III**

Futuristic KM: Knowledge Engineering, Theory of Computation, Data Structure.

**References:**

1. Knowledge Management – a resource book – A Thothathri Raman, Excel, 2004.
2. Knowledge Management- Elias M. AwadHasan M. Ghazri, Pearson Education
3. The KM Toolkit – Orchestrating IT, Strategy & Knowledge Platforms, AmritTiwana, Pearson, PHI, II Edn.
4. The Fifth Discipline Field Book – Strategies & Tools For Building A learning organizationPeterSenge et al. Nicholas Brealey 1994
5. Knowledge Management – Sudhir Warier, Vikas publications
6. Leading with Knowledge, MadanmohanRao, TataMc-Graw Hill.

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**Elective III, Group I:  
Foreign Language**

**Teaching Scheme:**

Lectures: 3 Hrs/Week

**Examination Scheme:**

Theory: In Semester: 50 Marks  
End Semester: 50 Marks  
**Credits:3**

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**Module I**

Pronunciation guidelines; Single vowels, Accentuated vowels, Vowels and consonants combinations, Consonants; Numbers 1-10 Articles and Genders; Gender in French, Plural articles, Some usual expressions. Pronouns and Verbs; The verb groups, The pronouns, Present tense, Some color Adjectives and Plural ; Adjectives, Some adjectives, Our first sentences, More Numbers.

**Module II:**

Sentences Structures; Some Prepositions, Normal Sentences, Negative Sentences, Interrogative Sentences, Exercises The Family; Vocabulary ,Conversation, Notes on Pronunciation, Notes on Vocabulary, Grammar, Liaisons Guideline. D'oùviens-tu (Where do you come from); Vocabulary, Conversation, Notes on Vocabulary, Liaisons Guidelines . Comparer (Comparing); Vocabulary, Conversation, Notes on Vocabulary, Grammar Liaisons Guidelines, Ordinal Numbers

**Module III:**

Le temps (Time); Vocabulary, Grammar, Time on the clock Additional French Vocabulary; Vocabulary related to - The Family, Vocabulary related to - Where do you come from? French Expressions and Idioms; Day-to-day Life, At Work, The car, Sports, Special Events Other French Flavours; Nos cousins d'Amérique - Québec et Acadie, Au pays de la bière et des frites, Mettez-vous à l'heure Suisse, Vé, peuchère, le françaisbien de chez nous

**Reference:** <http://www.jump-gate.com/languages/french/index.html>



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**Elective III, Group I:  
Engineering Economics**

**Teaching Scheme:**

Lectures: 3 Hrs/Week

**Examination Scheme:**

Theory: In Semester: 50 Marks

End Semester: 50 Marks

**Credits:3**

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**Module I:**

**Introduction to the subject:** Micro and Macro Economics, Relationship between Science, Engineering, Technology and Economic Development. Production Possibility Curve, Nature of Economic Law, **Time Value of Money:** concepts and application. Capital budgeting; Traditional and modern methods, Payback period method, IRR, ARR, NPV, PI (with the help of case studies)

**Module II:**

Meaning of Production and factors of production, Law of variable proportions and returns to scale. Internal and external economies and diseconomies of scale. Concepts of cost of production, different types of costs; accounting cost, sunk cost, marginal cost, Opportunity cost. Break even analysis, Make or Buy decision (case study). Relevance of Depreciation towards industry. Meaning of market, types of market, perfect competition, Monopoly, Monopolistic, Oligopoly. (Main features). Supply and law of supply, Role of demand and supply in price determination.

**Module III:**

Indian Economy, nature and characteristics. Basic concepts; fiscal and monetary policy, LPG, Inflation, Sensex, GATT, WTO and IMF. Difference between Central bank and Commercial banks

**Text Books:**

1. Jain T.R., Economics for Engineers, VK Publication
2. Singh Seema, Economics for Engineers, IK International

**Reference Books:**

1. Chopra P. N., Principle of Economics, Kalyani Publishers
2. Dewett K. K., Modern economic theory, S. Chand
3. H. L. Ahuja., Modern economic theory, S. Chand
4. DuttRudar&Sundhram K. P. M., Indian Economy
5. Mishra S. K., Modern Micro Economics, Pragati Publications
6. Pandey I.M., Financial Management; Vikas Publishing House
7. Gupta Shashi K., Management Accounting, Kalyani Publication

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**Elective III, Group I:  
Engineering Risk-Benefit Analysis**

**Teaching Scheme:**

Lectures: 3 Hrs/Week

**Examination Scheme:**

Theory: In Semester: 50 Marks

End Semester: 50 Marks

**Credits:3**

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**Module I**

Introduction- Knowledge and Ignorance, Information Uncertainty in Engineering Systems, Introduction and overview of class; definition of Engineering risk; overview of Engineering risk analysis. Risk Methods: Risk Terminology, Risk Assessment, Risk Management and Control, Risk Acceptance, Risk Communication, Identifying and structuring the Engineering risk problem; developing a deterministic or parametric model System Definition and Structure: System Definition Models, Hierarchical Definitions of Systems, and System Complexity.

**Module II**

Reliability Assessment: Analytical Reliability Assessment, Empirical Reliability Analysis Using Life Data, Reliability Analysis of Systems

**Module III**

Reliability and probabilistic risk assessment (RPRA), decision analysis (DA), and cost-benefit analysis (CBA). All of these pertain to decision making in the presence of significant uncertainty. In ERBA, the issues of interest are: The risks associated with large engineering projects such as nuclear power reactors, the International Space Station, and critical infrastructures; the development of new products; the design of processes and operations with environmental externalities; and infrastructure renewal projects

**Reference Books:**

1. Risk Analysis in Engineering and Economics, B. M. Ayyub, Chapman-Hall/CRC Press, 2003.
2. Hoyland, Arnljot, and Rausand, Marvin. *System Reliability Theory*. Hoboken, NJ: Wiley-Interscience, 1994. ISBN: 9780471471332.
3. Clemen, Robert, “ Making Hard Decisions: An Introduction to Decision Analysis (Business Statistics) “ PHI publications

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**Elective III, Group II:  
Optimization Techniques**

**Teaching Scheme:**

Lectures: 2 Hrs/Week

**Examination Scheme:**

Theory: In Semester: 50 Marks

End Semester: 50 Marks

**Credits:2**

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**Module I**

First and second order conditions for local interior optima (concavity and uniqueness), Sufficient conditions for unique global optima; Constrained optimization with Lagrange multipliers; Sufficient conditions for optima with equality and inequality constraints;

**Module II**

Recognizing and solving convex optimization problems. Convex sets, functions, and optimization problems. Least-squares, linear, and quadratic optimization. Geometric and semidefinite programming. Vector optimization. Duality theory. Convex relaxations. Approximation, fitting, and statistical estimation. Geometric problems. Control and trajectory planning

**Books:**

1. Stephen Boyd and Lieven Vandenberghe, *Convex Optimization*, Cambridge University Press.
2. A. Ben-Tal, A. Nemirovski, *Lectures on Modern Convex Optimization: Analysis, Algorithms, and Engineering Applications*, SIAM.
3. D. P. Bertsekas, A. Nedic, A. E. Ozdaglar, *Convex Analysis and Optimization*, Athena Scientific.
4. D. P. Bertsekas, *Nonlinear Programming*, Athena Scientific.
5. Y. Nesterov, *Introductory Lectures on Convex Optimization: A Basic Course*, Springer.
6. J. Borwein and A. S. Lewis, *Convex Analysis and Nonlinear Optimization: Theory and Examples* Springer.

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**Elective III, Group II:  
Fuzzy Mathematics**

**Teaching Scheme:**

Lectures: 2 Hrs/Week

**Examination Scheme:**

Theory: In Semester: 50 Marks

End Semester: 50 Marks

**Credits:2**

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**Module I**

Definition of a Fuzzy set; Elements of Fuzzy logic. Relations including, Operations, reflexivity, symmetry and transitivity; Pattern Classification based on fuzzy relations

**Module II:**

Fuzzy Models: Mamdani ,Sugeno, Tsukamoto

**Reference Books:**

1. Neuro-Fuzzy and Soft Computing by S.R.Jung, Sun, Mizutani,

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**Elective III, Group II:  
Design and Analysis of Algorithm**

**Teaching Scheme:**

Lectures: 2 Hrs/Week

**Examination Scheme:**

Theory: In Semester: 50 Marks

End Semester: 50 Marks

**Credits:2**

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**Module I :**

Introduction- Fundamental characteristics of an algorithm. Basic algorithm analysis –Asymptotic analysis of complexity bounds– best, average and worst-case behaviour, standard notations for expressing algorithmic complexity. Empirical measurements of performance, time and space trade-offs in algorithms.

**Module II:**

Properties of big-Oh notation – Recurrence equations – Solving recurrence equations – Analysis of linear search. Divide and Conquer: General Method – Binary Search – Finding Maximum and Minimum – Merge Sort – Greedy Algorithms: General Method – Container Loading – Knapsack

**Reference Books:**

1. Algorithm Design – Jon Kleinberg and Eva Tardos
2. Introduction to Algorithms – T.H. Cormanet. Al

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**Elective III, Group II:  
CUDA**

**Teaching Scheme:**

Lectures: 2 Hrs/Week

**Examination Scheme:**

Theory: In Semester: 50 Marks

End Semester: 50 Marks

**Credits:2**

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**Module I**

History of GPUs leading to their use and design for HPC- The Age of Parallel Processing, The Rise of GPU Computing ,CUDA, Applications of CUDA, Development Environment, Introduction to CUDA C, Kernel call, Passing Parameters, Querying Devices, Using Device Properties

**Module II:**

Parallel Programming in CUDA C - CUDA Parallel Programming, Splitting Parallel Blocks, Shared Memory and Synchronization, Constant Memory, Texture Memory, CUDA events, Measuring Performance with Events.

**Books:**

1. Programming Massively Parallel Processors: A Hands-on Approach –second edition by David B. Kirk, Wen-mei W. Hwu.
2. CUDA by Example - An Introduction to General-Purpose GPU Programming by Jason Sanders ,Edward Kandrot- Addison Wesley
3. GPU Computing Gems Emerald Edition -Applications of GPU Computing Series by Wen-mei, W. Hwu
4. CUDA Programming: A Developer's Guide to Parallel Computing with GPUs by shane cook

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**Seminar II**

**Teaching Scheme:**  
**Practical 4 Hrs/ Week**

**Examination Scheme:**  
**Term Work : 50 Marks**  
**Oral/ Presentation: 50**  
**Marks**  
**Credits :4**

**Seminar II:** Shall be on the topic relevant to latest trends in the field of concerned branch, preferably on the topic of specialization based on the electives selected by him/her approved by authority. The student shall submit the seminar report in standard format, duly certified for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

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## **Project Stage- I**

**Teaching Scheme:**  
**Practical 8 Hrs/ Week**

**Examination Scheme:**  
**Term Work : 50 Marks**  
**Oral/ Presentation: 50**  
**Marks**  
**Credits :8**

### **Project Stage – I**

Project Stage – I is an integral part of the project work. In this, the student shall complete the partial work of the project which will consist of problem statement, literature review, project overview, scheme of implementation (Mathematical Model/SRS/UML/ERD/block diagram/ PERT chart, etc.) and Layout & Design of the Set-up. As a part of the progress report of Project work Stage-I, the candidate shall deliver a presentation on the advancement in Technology pertaining to the selected dissertation topic.

The student shall submit the duly certified progress report of Project work Stage-I in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

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**Seminar III**

**Teaching Scheme:**  
**Practical 5 Hrs/ Week**

**Examination Scheme:**  
**Term Work : 50 Marks**  
**Oral/ Presentation: 50**  
**Marks**  
**Credits :5**

**Seminar III**:shall preferably an extension of **seminar II**. The student shall submit the dulycertified seminar report in standard format, for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

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**Project Stage- II**

**Teaching Scheme:  
Practical 20 Hrs/  
Week**

**Examination Scheme:  
Term Work : 150  
Marks  
Oral/ Presentation: 50  
Marks  
Credits :20**

**Project Stage – II**

In Project Stage – II, the student shall complete the remaining part of the project which will consist of the fabrication of set up required for the project, work station, conducting experiments and taking results, analysis & validation of results and conclusions.

The student shall prepare the duly certified final report of project work in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute.