Department of Electronics & Communication Engineering
राष्ट्रीय प्रौद्योगिकी संस्थान,मणिपुर
NATIONAL INSTITUTE OF TECHNOLOGY MANIPUR
Langol, Imphal – 795 004, Ph. (0385)2445812, e-mail: hodece@nitmanipur.ac.in
(An Autonomous Institute under MHRD, Govt. of India)

M.Tech.

IN

Communication and Signal Processing

CURRICULUM AND SYLLABUS

(Applicable from 2026 onwards)

Department of Electronics & Communication Engineering

NATIONAL INSTITUTE OF TECHNOLOGY MANIPUR

Langol Road, Lamphelpat, Imphal, Manipur - 795004

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PROPOSED SYLLABUS FOR M. TECH. IN COMMUNICATION AND SIGNAL PROCESSING

Program Outcomes (POs) of the M.Tech. Program in Communication and Signal Processing:

Engineering Masters will be able to:

- Interpret, analyse and process the communication signals, data using appropriate modern techniques and tools.
- Analyse and evaluate the modulation and detection techniques for a communication network and suggest enhancements.
- Ability to use software and hardware-based approach in design, analysis and implementation of various signal processing algorithms and communication-based systems for different applications.
- Applications in Signal Processing and its various algorithms for system optimization and design optimal coding schemes for efficient use of channel capacity using appropriate modern techniques and tools.
- Ability to plan, implement and operate state of the art communication and networking equipment and modern software tools.
- Ability to specify and architect a communication system suitable for given application as per international standards using necessary signal processing algorithm.
- Ability to design and operate Software Defined Radio systems and identify the components of a multimedia communication system.
- Ability to apply suitable tools to design, simulate and demonstrate the working of mobile cellular networks and routing of data as per the societal needs.
- Ability to specify and architect an optimal coding scheme for communication system suitable for given application as per international standards and suggest enhancements for efficient use of channel capacity
- Work in a team and contribute collaboratively in multi-disciplinary research in the field of sensor networks to achieve the project objectives.
- Pursue life-long learning as a means of enhancing the knowledge and skills.

The Programme Educational Objectives (PEOs) are,

1. Specify the communication system for a given requirement.
2. Select coding technique for efficient transmission and reception and to provide required security. Model, simulate, design and implement the communication and computer network systems as per the specifications.
3. Apply the knowledge of communications and networking areas to innovatively solve the problems of changing world using modern engineering tools.
4. Pursue life-long learning as a means of enhancing the knowledge base and skills necessary to serve the engineering and scientific community.
5. Contribute as an individual or a member of a team in product-oriented research and demonstrate leadership skills.

The Programme Specific Objectives (PSOs) are,

1. To design and develop electronic systems which optimize power and area requirements, free from faults and dependencies by modelling, simulation and testing.

2. To develop electronic systems by learning advanced algorithms, architectures and software-hardware co-design.
3. To communicate engineering concepts effectively by exhibiting high standards of technical presentations and scientific documentations.

SEMESTER-I

Course Code	Course Title	L	T	P	C
EC 5101	Next-Generation Antenna Technologies	3	1	0	4
EC 5102	Information Theory and Coding	3	1	0	4
EC 5103	Modern Wireless Communication	3	1	0	4
EC 5104	Signal Processing Algorithms	3	0	0	3
EC 515x	Elective-I	3	0	0	3
EC 516x	Elective-II	0	0	6	3
EC 5110	Seminar-I	0	0	4	2
		Total:			23

SEMESTER-II

Course Code	Course Title	L	T	P	C
EC 5201	Image Processing Techniques	3	1	0	4
EC 5202	Modern Digital Communication Techniques	3	1	0	4
EC 5203	Microwave and Terahertz Engineering	3	1	0	4
EC 5204	Communication Networks	3	0	0	3
EC 525x	Elective-III	3	0	0	3
EC 526x	Elective-IV	0	0	6	3
EC 5210	Seminar-II	0	0	4	2
		Total:			23

SEMESTER-III

Course Code	Course Title	L	T	P	C
EC 6301	Project-I	0	0	24	12
EC 6310	Comprehensive Viva	0	0	4	2
		Total:			14

SEMESTER-IV

Course Code	Course Title	L	T	P	C
EC 6401	Project-II	0	0	40	20
		Total:			20

Elective-I

Course Code	Course Title	L	T	P	C
EC 5151	Applied Digital Signal Processing	3	0	0	3
EC 5152	Mobile Communication	3	0	0	3
EC 5153	Fiber Optics Communication	3	0	0	3
EC 5154	Software Defined Radio	3	0	0	3
EC 5155	Electromagnetic Modeling and Simulation	3	0	0	3
EC 5156	Antenna Systems for Mobile Communications	3	0	0	3
EC 5157	Electromagnetic Interference	3	0	0	3
EC 5158	Principle of Microwave solid state devices	3	0	0	3
EC 5159	5G Massive MIMO: Principles, Architecture and Applications	3	0	0	3

Elective-II

Course Code	Course Title	L	T	P	C
EC 5161	Advanced Microwave and Antenna Lab	0	0	6	3
EC 5162	Communication System Lab	0	0	6	3
EC 5163	Signal Processing Lab	0	0	6	3

Elective-III

Course Code	Course Title	L	T	P	C
EC 5251	Data Communication	3	0	0	3
EC 5252	Satellite Communication	3	0	0	3
EC 5253	Advance Radio Communication	3	0	0	3
EC 5254	Microwave Devices and Circuits	3	0	0	3
EC 5255	RF Components & Circuit Design	3	0	0	3
EC 5256	Radar Engineering	3	0	0	3
EC 5257	Advance EM Wave Propagation and Antenna	3	0	0	3
EC 5258	Microwave Filter Design	3	0	0	3
EC 5259	Research Methodology for Engineers	3	0	0	3

Elective-IV

Course Code	Course Title	L	T	P	C
EC 5263	Advanced Communication Lab	0	0	6	3
EC 5264	Image Processing Lab	0	0	6	3

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Detailed Syllabus and Course Outcomes

Course Code: EC 5101	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory		
Course Title	Next-Generation Antenna Technologies **(EC 5101)**		
Course Objectives	• To introduce the fundamental concepts, parameters, and radiation mechanisms of antennas. • To analyze radiation characteristics and performance of linear and array antennas. • To study various advanced antenna structures and compare their characteristics and applications. • To design and analyze microstrip antennas and antenna arrays for modern wireless communication systems.		

Course Outcomes		**Cognitive Levels**
CO1	Understand antenna fundamentals, radiation mechanisms, antenna parameters, and various radiation zones.	Knowledge/Comprehension (Level-I/Level-II)
CO2	Analyze the radiation characteristics and operational principles of dipole antennas and antenna arrays.	Analysis (Level-IV)
CO3	Compare different antenna types and evaluate their applications in communication and microwave systems.	Analysis/Evaluation (Level-IV/Level-V)
CO4	Design microstrip antennas and analyze field distribution, feeding methods, and radiation characteristics for practical applications.	Application/Synthesis (Level-III/Level-VI)

Semester	**I**	**Summer**

Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	1	0	3	48

Prerequisite course codes with course names	Electromagnetic Theory Microwave Engineering Antennas and Wave Propagation

Text Books		
1.	Title	Antenna Theory: Analysis and Design
	Author	C. A. Balanis
	Publisher	John Wiley & Sons
	Edition	2009
2.	Title	Antennas and Wave Propagation
	Author	R. J. Marhefka, A. S. Khan and J. D. Kraus
	Publisher	Tata McGraw-Hill Education
	Edition	2010
3.	Title	Antennas and Wave Propagation

	Author	M. Sachidananda and A. R. Harish	
	Publisher	Oxford University Press	
	Edition	2007	
Reference Books			
1.	Title	Modern Antenna Design	
	Author	Thomas A. Milligan	
	Publisher	Wiley	
	Edition	2nd Edition	
2.	Title	Microstrip Antennas	
	Author	David M. Pozar and Daniel H. Schaubert	
	Publisher	IEEE Press	
	Edition	1995	
3.	Title	Advanced Engineering Electromagnetics	
	Author	Constantine A. Balanis	
	Publisher	Wiley	
	Edition	2012	
Course Contents	**UNIT I: Fundamentals of Antennas and Radiation Mechanism** Basic concepts of antennas; antenna parameters: radiation pattern, gain, directivity, efficiency, bandwidth, polarization, input impedance; different radiation zones: reactive near field, radiating near field, and far field regions; mechanism of electromagnetic radiation; scattering parameters and their significance in antenna analysis.		**12**
	UNIT II: Linear Antennas and Antenna Arrays Radiation mechanism of linear antennas; dipole antennas and their characteristics; current distribution and radiation pattern analysis; folded dipole antennas; antenna arrays and array factor; broadside and end-fire arrays; phased arrays and beam steering concepts; radiation analysis and performance evaluation.		**12**
	UNIT III: Advanced Antenna Structures and Applications Horn antennas and applications; slot antennas; substrate integrated waveguide (SIW) antennas; dielectric resonator antennas (DRA); helical antennas; log-periodic antennas; comparison of antenna characteristics such as bandwidth, gain, polarization, and applications in radar, satellite, and wireless communication systems.		**12**
	UNIT IV: Microstrip Antenna Design and Analysis Microstrip antenna fundamentals and structure; feeding techniques: coaxial feed, microstrip line feed, aperture coupling, and proximity coupling; field distribution and radiation mechanism; surface wave propagation effects; design methodology of rectangular microstrip antennas; microstrip array antennas; simulation and performance analysis parameters including return loss, VSWR, gain, and radiation pattern.		**12**

Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%

Course Code: EC 5102	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**		
	N	Y	N		
Type of Course	Theory				
Course Title	**Information Theory an coding (EC5102)**				
Course Objectives	• This course will introduce the student to the various aspect of the information theories and their coding, to implement the algorithms of coding. • To Various array design methods and direction of arrival estimation techniques are discussed in this course.				
Course Outcomes					**Cognitive Levels**
CO1	Learn and apply the concepts of different coding techniques for data transmission.				Knowledge/Comprehension (Level I/Level-II)
CO2	To solve classical problems with linear blocks.				Analysis (Level-IV)
CO3	Analyze information using various encoding techniques				Application (Level-III)
CO4	Monitor performance of encoding techniques in the application of data transmission.				Synthesis/Evaluation (Level-VI/Level-V)
Semester	**I**		**Summer**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Basics of Digital Communication. (EC 2402)				
Text Books					
1.	Title	Information Theory, Coding and Cryptography, Publication, 2005			
	Author	Ranjan Bose			
	Publisher	McGraw-Hill			
	Edition	3rd Edition			
2.	Title	Elements of Information Theory. ISBN: 9780471241959			
	Author	Cover, Thomas, and Joy Thomas.			
	Publisher	Wiley-Inter science			
	Edition	2nd ed. New York, NY: 2006.			

Reference Books			
1.	Title	Digital Communications,",	
	Author	John G. Proakis and Masoud Salehi,	
	Publisher	McGraw Hill	
	Edition	5th edition	
Course Contents	**UNIT 1** **INTRODUCTION:** Information – Entropy, Information rate, classification of codes, Kraft McMillan inequality, Source coding theorem, Shannon-Fano coding, Huffman coding, Extended Huffman coding - Joint and conditional entropies, Mutual information - Discrete memory less channels – BSC, BEC – Channel capacity, Shannon limit, Shannon's First Theorem.		**9**
	UNIT 2 Review: Algebra, Krawtchouk Polynomials, Combinatorial Theory, Probability Theory. Linear Codes: Block Codes, Linear Codes, Hamming Codes, Repetition codes - Linear block codes, Cyclic codes- Syndrome calculation, Encoder and decoder – CRC, Convolution codes – code tree, trellis, state diagram - Encoding – Decoding: Sequential search and Viterbi algorithm – Principle of Turbo coding.		**9**
	UNIT 3 Majority Logic Coding, Weight Enumerators, The Lee Metric, Hadamard Codes, Golay Codes (Binary and Ternary), Reed Muller Codes, Linear Programming Bounds, Hamming's Sphere –Packing Bound, Gilbert Varshamov Bound, Hadamard Matrices and Codes.		**9**
	UNIT 4 Arithmetic Coding, LZW algorithm – Audio: Perceptual coding, Masking techniques, Psychoacoustic model, MEG Audio layers I, II, III, Dolby AC3-Speech: Channel Vocoder, Linear Predictive Coding.		**9**
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: **EC 5103**	Open Elective Course: (Y/N)	Departmental Core Course: (Y/N)	Departmental Elective Course: (Y/N)
	N	Y	N
Type of Course	Theory		
Course Title & Code	**Modern Wireless Communication (EC 5103)**		
Course Objectives	• To introduce the fundamental concepts, historical evolution, and architecture of modern wireless communication systems.		

	• To understand radio propagation mechanisms, fading characteristics, channel modeling, and techniques for improving system capacity and spectrum efficiency. • To study multiple access techniques, cellular concepts, handoff mechanisms, spread spectrum communication, and mobile communication standards such as GSM and CDMA. • To provide knowledge of wireless data networking, mobile IP, transport protocols over wireless channels, and emerging mobile communication technologies.

Course Outcomes		Cognitive Levels
CO1	Understanding the historical background of wireless communication and its evolution.	Knowledge/Comprehension (Level I/Level-II)
CO2	Assimilating the concepts of increasing system capacity.	Application (Level-III)
CO3	Learning the effects of fading channels and various cellular interferences.	Analysis (Level-IV)
CO4	Enquiry to latest cellular technologies.	Synthesis/Evaluation (Level-VI/Level-V)

Semester	VI	Summer			
Contact Hours	Lecture	Tutorial	Practical	Credits	Total Teaching Hours
	3	0	0	3	36
Prerequisite course codes with course names	Analog Communication; Digital Communication;				

Text Books		
1.	Title	Wireless Communications and Networks
	Author	William Stallings
	Publisher	Pearson Education
	Edition	2002 or Latest
2.	Title	Principles of Wireless Networks
	Author	Kaveh Pahlavan, Prasanth Krishnamoorthy
	Publisher	Pearson Education
	Edition	1st 2003 or Latest

Reference Books		
1.	Title	Wireless Communication
	Author	Andrea Goldsmith
	Publisher	Cambridge University Press
	Edition	2005 or Latest

Course Contents	UNIT I: Cellular concepts, frequency reuse, co channel interference, Cell splitting. Radio propagation characteristics; models for path loss, shadowing and multipath fading (delay spread, coherence bandwidth coherence time. Doppler spread).	9

	UNIT II: Jakes' channel model. Digital modulation for mobile radio; analysis under fading channels; diversity techniques and Rake demodulator. Introduction to spread spectrum communication. Multiple access techniques used in mobile wireless communications: FDMA/TDMA, CDMA.	9
	UNIT III: The cellular concept: Frequency reuse; the basic theory of hexagonal cell layout; spectrum efficiency. FDM/TDM Cellular systems; channel allocation schemes. Handover analysis. Cellular CDMA; soft capacity. Erring capacity comparison of FDM/TDM systems and cellular CDMA. Discussion of GSM standards; signaling and call control; mobility management; location tracing.	9
	UNIT IV: Wireless data networking; packet error modeling on fading channels, performance analysis of link and transport layer protocols over wireless channels; mobile data networking (mobile IP); wireless data in GSM, IS-95, and GPRS.	9
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%

Course Code: EC 5104	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory		
Course Title	**Signal Processing Algorithms (EC 5104)**		
Course Objectives	• To provide knowledge of orthogonal transforms and their applications in one-dimensional and two-dimensional signal processing. • To understand the implementation of digital filters using transform techniques and efficient realization structures. • To study computational complexity and realization methods for FIR and IIR digital filters. • To introduce multirate signal processing techniques and efficient sampling rate conversion algorithms.		

Course Outcomes		**Cognitive Levels**
CO1	Understand and analyze orthogonal transforms such as DFT, DCT, and HAAR for one-dimensional and two-dimensional signals.	Knowledge/Comprehension/Analysis (Level-I/Level-II/Level-IV)
CO2	Apply transform techniques for the design and implementation of FIR and IIR digital filters.	Application (Level-III)
CO3	Analyze FIR/IIR filter structures and realization techniques for computational and design efficiency.	Analysis (Level-IV)
CO4	Evaluate multirate signal processing algorithms and efficient sampling rate conversion techniques for digital signal processing applications.	Evaluation/Synthesis (Level-V/Level-VI)

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Semester	**I**			**Summer**	
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Signals and Systems Digital Signal Processing Linear Algebra and Transform Theory				

Text Books			
1.	Title	Digital Signal Processing and Applications with TMS320C6713 and TMS320C6416	
	Author	R. Chassaing and D. Reay	
	Publisher	Wiley	
	Edition	2008	
2.	Title	Digital Signal Processing: A Computer Based Approach	
	Author	S. K. Mitra	
	Publisher	TMH	
	Edition	3rd Edition, 2008	
3.	Title	Digital Signal Processing: Principles, Algorithms and Applications	
	Author	J. G. Proakis and D. G. Manolakis	
	Publisher	Pearson Prentice Hall	
	Edition	2007	
Reference Books			
1.	Title	Multirate Systems and Filter Banks	
	Author	P. P. Vaidyanathan	
	Publisher	Pearson	
	Edition	1993	
2.	Title	Discrete-Time Signal Processing	
	Author	A. V. Oppenheim and R. W. Schafer	
	Publisher	Pearson	
	Edition	3rd Edition	
3.	Title	Modern Digital and Analog Communication Systems	
	Author	B. P. Lathi	
	Publisher	Oxford University Press	
	Edition	4th Edition	
Course Contents	**UNIT I: Orthogonal Transforms and FFT Algorithms** Orthogonal transforms for one-dimensional and two-dimensional signals; discrete Fourier transform (DFT), discrete cosine transform (DCT), and HAAR transform; properties of DFT; computation of DFT using FFT algorithms; decimation-in-time (DIT) FFT and decimation-in-frequency		**9**

	(DIF) FFT structures; computational aspects of FFT; linear convolution using DFT.	
	UNIT II: Digital Filter Structures and Realization Techniques Basic FIR and IIR digital filter structures; direct form, cascade form, and parallel form realizations; FIR and IIR lattice and cascaded lattice structures; realization of IIR transfer functions using parallel all-pass structures; sine-cosine generator; transform-based digital filter design techniques; applications of FIR and IIR filters.	**9**
	UNIT III: Computational Complexity and Efficient Filter Realization Computational complexity analysis of digital filter structures; memory and arithmetic requirements; numerical properties of filter realizations; finite word-length effects; stability considerations; efficient implementation techniques for FIR/IIR filters; optimization of filter structures for DSP applications.	**9**
	UNIT IV: Multirate Signal Processing and Sampling Rate Conversion Multirate signal processing fundamentals; decimators and interpolators; basic structures for sampling rate conversion; multistage implementation of interpolators and decimators; polyphase decomposition and FIR structures; computationally efficient sampling rate converters; arbitrary sampling rate conversion using Lagrange and spline interpolation; quadrature mirror filter banks; conditions for perfect reconstruction; applications in sub-band coding.	**9**
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%

Course Code: EC 5151	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory		
Course Title	Applied Digital Signal Processing **(EC 5151)**		
Course Objectives	• To provide advanced knowledge of statistical and parametric methods used in signal and image processing. • To understand adaptive signal processing algorithms and their practical applications. • To study multirate signal processing techniques and efficient FIR filter structures. • To introduce advanced transform techniques including wavelet transforms and time-frequency signal analysis.		

Course Outcomes		**Cognitive Levels**
CO1	Understand and analyze various parametric estimation methods used in signal and image processing applications.	Knowledge/Comprehension/Analysis

		(Level-I/Level-II/Level-IV)
CO2	Apply adaptive signal processing algorithms such as LMS and RLS in practical signal processing applications.	Application (Level-III)
CO3	Analyze and implement FIR structures and multirate signal processing techniques for sampling rate conversion.	Analysis/Application (Level-IV/Level-III)
CO4	Evaluate signals and systems in the frequency domain using linear prediction methods and wavelet transform techniques	Evaluation/Synthesis (Level-V/Level-VI)

Semester	**I**		**Summer**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Signals and Systems Digital Signal Processing Probability and Random Processes				

Text Books		
1.	Title	Digital Signal Processing: Principles, Algorithms and Applications
	Author	John G. Proakis and Dimitris G. Manolakis
	Publisher	PHI
	Edition	3rd Edition, 2000
2.	Title	Statistical Digital Signal Processing and Modeling
	Author	Monson H. Hayes
	Publisher	Wiley
	Edition	2002
3.	Title	Digital Processing of Speech Signals
	Author	L. R. Rabiner and R. W. Schafer
	Publisher	Pearson Education
	Edition	1979
4.	Title	Modern Digital Signal Processing
	Author	Roberto Cristi
	Publisher	Thomson Brooks/Cole
	Edition	2004
5.	Title	Wavelet Transforms: Introduction to Theory and Applications
	Author	Raghuveer M. Rao and Ajit S. Bopardikar
	Publisher	Pearson Education Asia
	Edition	2000
Reference Books		
1.	Title	Adaptive Filter Theory
	Author	Simon Haykin

	Publisher	Pearson	
	Edition	5th Edition	
2.	Title	Multirate Systems and Filter Banks	
	Author	P. P. Vaidyanathan	
	Publisher	Pearson	
	Edition	1993	
3.	Title	Wavelets and Filter Banks	
	Author	Gilbert Strang and Truong Nguyen	
	Publisher	Wellesley Cambridge Press	
	Edition	1996	
Course Contents	**UNIT I: Parametric Spectral Estimation Methods** Parametric methods for power spectrum estimation; relationship between autocorrelation and model parameters; Yule-Walker method for AR model parameter estimation; Burg method for AR model parameters; unconstrained least-squares method; sequential estimation methods for AR model parameters; selection of AR model order; applications in signal and image processing.		**9**
	UNIT II: Adaptive Signal Processing Algorithms FIR adaptive filters; steepest descent adaptive filter; least mean square (LMS) algorithm; convergence analysis of LMS algorithm; applications in noise cancellation and channel equalization; adaptive recursive filters; recursive least squares (RLS) algorithm and performance analysis.		**9**
	UNIT III: Multirate Signal Processing and Linear Prediction Multirate signal processing fundamentals; decimation by factor D and interpolation by factor I; filter design and implementation for sampling rate conversion; direct form FIR structures; polyphase filter structures; innovations representation of stationary random processes; forward and backward linear prediction; solution of normal equations; Levinson-Durbin and Schur algorithms; Wiener filtering and prediction.		**9**
	UNIT IV: Time-Frequency Analysis and Wavelet Transforms Fourier transform: power and limitations; short-time Fourier transform (STFT); Gabor transform; discrete-time Fourier transform and filter banks; continuous wavelet transform; wavelet transform ideal case; perfect reconstruction filter banks and wavelets; recursive multiresolution decomposition; Haar wavelet and Daubechies wavelet; applications of wavelet transforms in signal processing.		**9**
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

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Course Code: **EC 5152**	Open Elective Course: (Y/N)	Departmental Core Course: (Y/N)	Departmental Elective Course: (Y/N)
	N	Y	Y

Type of Course	Theory
Course Title & Code	**Mobile Communication (EC 5152)**
Course Objectives	• To provide fundamental knowledge of modern wireless communication systems, cellular concepts, and the historical evolution of wireless technologies. • To understand radio wave propagation characteristics, fading mechanisms, interference effects, and techniques for improving system capacity and spectrum efficiency. • To study digital modulation techniques, spread spectrum communication, multiple access methods, and cellular standards used in modern mobile communication systems. • To introduce wireless data networking concepts, mobile IP, packet error modeling, and emerging wireless communication technologies such as GSM, IS-95, and GPRS.

Course Outcomes		Cognitive Levels
CO1	Familiarization with various cellular mobile systems technologies.	Knowledge/Comprehension (Level I/Level-II)
CO2	Concepts of cell coverage and antenna associated cellular communication.	Application (Level-III)
CO3	Application of frequency reuse and channel assignments.	Analysis (Level-IV)
CO4	Learning various multiple assess techniques and uncoming techniques.	Synthesis/Evaluation (Level-VI/Level-V)

Semester	VI	Summer

Contact Hours	Lecture	Tutorial	Practical	Credits	Total Teaching Hours
	3	0	0	3	36

Prerequisite course codes with course names	Analog Communication; Digital Communication;

Text Books		
1.	Title	Mobile Cellular Telecommunications
	Author	William, C Y Lee
	Publisher	McGraw Hill
	Edition	2nd Edition or Latest
2.	Title	Mobile wireless communications
	Author	Mischa Schwartz
	Publisher	Cambridge University press
	Edition	2005 or Latest
Reference Books		

1.	Title	Mobile Communication Hand Book	
	Author	Jerry D. Gibson	
	Publisher	IEEE Press	
	Edition	2nd Edition	
Course Contents	UNIT I: Introduction to Cellular Mobile Systems: Cellular system, performance criteria, planning a cellular system. Cellular Radio Systems Design, General description of the problem, concept of frequency reuse channels, co-channel interference, reduction factor, desired C/I from a normal case in an omni directional antenna system, cell splitting. Introduction to co-channel interference, co-channel measurement design of antenna system, antenna parameter and their effects.		9
	UNIT II: Cell Coverage for Signal & antenna structures: General introduction, obtaining the mobile point to point mode, propagation over water or flat open area, foliage loss, propagation near in distance, long distance propagation, point to point prediction model- characteristics, cell site, antenna heights and signal coverage cells, mobile to mobile propagation.		9
	UNIT III: Characteristics of basic antenna structures, antenna at cell site, mobile antennas. Frequency Management & Channel Assignment, Hand Off & Dropped Calls: Frequency assignment, non- fixed channel assignment, traffic & channel assignment. Hand off, types of handoffs and their characteristics, dropped call rates & their evaluation.		9
	UNIT IV: Modulation methods and coding for error detection and correction: Introduction to Digital modulation techniques, modulation methods in cellular wireless systems, OFDM. Block coding, convolution coding and Turbo coding. Multiple access techniques: FDMA, TDMA, CDMA; Time-division multiple access (TDMA), code division multiple access (CDMA). 5G and beyond.		9
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: EC 5153	Open Elective Course: (Y/N)	Departmental Core Course: (Y/N)	Departmental Elective Course: (Y/N)
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	**Fiber Optics Communication** (EC 5153)		
Course Objectives	• To introduce basics of signal propagation through optical fibers. • To introduce the fiber impairments, optical components and devices. • To learn all design considerations of optical fiber systems. • To learn about the optical sources.		
Course Outcomes			Cognitive Levels
CO1	To be able to recognize and classify the structures of Optical fiber and types.		Knowledge/Comprehension (Level I/Level-II)

CO2	To discuss the channel impairments like losses and dispersion.	Analysis (Level-IV)
CO3	Classify the Optical sources and detectors and to discuss their principle.	Application (Level-III)
CO4	Familiar with Design considerations of fiber optic systems.	Synthesis/Evaluation (Level-VI/Level-V)

Semester	I		Summer		
Contact Hours	Lecture	Tutorial	Practical	Credits	Total Teaching Hours
	3	0	0	3	36
Prerequisite course codes with course names	Electromagnetic Theory (EC 3502)				

Text Books			
1.	Title	Optical Fiber Communications	
	Author	Gerd KeiserGerd Keiser	
	Publisher	McGraw-Hill Education, 2010	
	Edition	4thEdition	
2.	Title	Introduction To Fiber Optics	
	Author	ajoy ghatak, k. Thyagarajan	
	Publisher	Cambridge University Press, 1998	
	Edition	1st Edition	
Reference Books			
1.	Title	Fiber Optic Communication Systems	
	Author	G.P. Agrawal	
	Publisher	Wiley, 2002	
	Edition	3rd Edition	
2.	Title	Optical Communication Systems	
	Author	John Gowar	
	Publisher	Prentice Hall. 2001	
	Edition	2nd Edition	
Course Contents	UNIT I: Overview of Optical Fibers Introduction to vector nature of light, propagation of light, Ray model, wave model.Optical Fibers: Structure, Types, Waveguiding. Step-index and graded index optical fibers. Modal analysis. Classification of modes. Single Mode Fibers.		9
	UNIT II: Signal Degradation In Optical Fibers Attenuation. Pulse dispersion. Material and waveguide dispersion. Polarization Mode Dispersion. Absorption, scattering and bending losses. Dispersion Shifted Fibers, Dispersion Compensating Fibers.		9
	UNIT III: Optical Power Launching and Coupling		9

	Source To Fiber Power Launching. Lensing schemes for coupling improvement. Fiber-to-fiber joints. Splicing techniques. Connectors. Optical fiber connectors.	
	UNIT IV: Optical sources and Fiber Optics Systems Laser fundamentals. Semiconductor Laser basics. LEDs. PIN and Avalanche photodiodes. Analog and digital modulation. Noise in detection process. Bit error rate. Optical receiver operation. Power Budget and Rise time Budget. Introduction to optical amplifiers (EDFA), Overview of WDM, Passive optical couplers, Isolators and Circulators.	9
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%

Course Code: EC 5154	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y

Type of Course	Theory
Course Title	**Software Defined Radio (EC 5154)**
Course Objectives	• To introduce the concepts, history, and evolution of Software Defined Radio (SDR) systems. • To understand SDR architectures, spectrum utilization, and software communication frameworks. • To study intelligent radio systems, adaptive techniques, and smart antenna technologies in SDR. • To explore low-cost SDR platforms, military-commercial convergence, and future trends in SDR technology.

Course Outcomes		**Cognitive Levels**
CO1	Understand the historical evolution, concepts, benefits, and communication principles of Software Defined Radio systems.	Knowledge/Comprehension (Level-I/Level-II)
CO2	Analyze frequency spectrum utilization, SDR architectures, and software communication frameworks for modern wireless systems.	Analysis (Level-IV)
CO3	Evaluate intelligent radio systems, adaptive signal processing techniques, and smart antenna architectures in SDR applications.	Analysis/Evaluation (Level-IV/Level-V)
CO4	Apply SDR principles in practical wireless systems and assess future trends, low-cost SDR platforms, and military-commercial convergence technologies.	Application/Synthesis (Level-III/Level-VI)

Semester	**I**	**Summer**

Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36

Prerequisite course codes with course names	Digital Communication Wireless Communication Digital Signal Processing RF and Microwave Engineering	
Text Books		
1.	Title	Software Defined Radio: Architectures, Systems and Functions
	Author	Dillinger, Madani and Alonistioti (Eds.)
	Publisher	Wiley
	Edition	2003
2.	Title	Software Radio
	Author	Joseph Mitola Reed
	Publisher	Pearson
	Edition	1997
3.	Title	Software Defined Radio for 3G
	Author	Paul Burns
	Publisher	Artech House
	Edition	2002
Reference Books		
1.	Title	Technologies for the Wireless Future
	Author	R. Tafazolli (Ed.)
	Publisher	Wiley
	Edition	2005
2.	Title	Software Defined Radio: The Software Communications Architecture
	Author	Jonathan Bard and Vincent Kovarik
	Publisher	Wiley
	Edition	2007
3.	Title	Cognitive Radio Technology
	Author	Bruce Fette
	Publisher	Elsevier
	Edition	2nd Edition
Course Contents	**UNIT I: Fundamentals and History of Software Defined Radio** Introduction to Software Defined Radio (SDR); history and evolution of SDR; benefits and applications of SDR; SDR Forum and standardization activities; ideal SDR architecture; SDR-based end-to-end communication systems; overview of worldwide frequency band plans; spectrum utilization concepts and challenges.	**9**
	UNIT II: SDR Architectures and Communication Frameworks Aim and requirements of Software Communications Architecture (SCA); SDR architecture overview and functional view; networking overview; core	**9**

	framework concepts; real-time operating systems (RTOS) in SDR; Common Object Request Broker Architecture (CORBA); SCA and Joint Tactical Radio System (JTRS) compliance; SDR system integration and spectrum management techniques.	
	UNIT III: Intelligent Radios and Smart Antenna Systems Radio frequency design for SDR systems; baseband signal processing; radios with intelligence and cognitive capabilities; adaptive signal processing techniques; smart antennas and phased array antennas; applying SDR principles to antenna systems; smart antenna architectures and beamforming concepts; adaptive wireless communication systems.	**9**
	UNIT IV: SDR Platforms, Applications and Future Trends Low-cost SDR platforms and implementation challenges; SDR hardware and software requirements; SDR system architecture; convergence between military and commercial communication systems; security and interoperability considerations; future prospects of Software Defined Radio; emerging wireless technologies and next-generation SDR applications.	**9**
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%

Course Code: EC 5155	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory		
Course Title	Electromagnetic Modeling and Simulation **(EC 5155)**		
Course Objectives	• To introduce advanced electromagnetic field theory and Maxwell's equations. • To develop understanding of EM wave propagation, transmission lines, and waveguide structures. • To provide knowledge of computational electromagnetics and modern electromagnetic applications in communication and microwave systems.		

Course Outcomes		**Cognitive Levels**
CO1	Understand advanced vector analysis and Maxwell's equations for electromagnetic field analysis.	Knowledge/Comprehension (Level I/Level-II)
CO2	Analyze electromagnetic wave propagation and field behavior in different media.	Analysis (Level-IV)
CO3	Apply transmission line and waveguide concepts for microwave and communication systems.	Application (Level-III)
CO4	Evaluate advanced electromagnetic applications, computational methods, and modern EM technologies.	Synthesis/Evaluation (Level-VI/Level-V)

Semester	**I**			**Summer**	
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Electromagnetic Theory (EC 3502)				
Text Books					
1.	Title	Time Harmonic Electromagnetics			
	Author	R. F Harrington.			
	Publisher	McGraw Hill			
	Edition	Reprint, 1961.			
2.	Title	Field Computation by Moment Methods			
	Author	RF Harrington			
	Publisher	MacMillan			
	Edition	Reprint, 1968			
Reference Books					
1.	Title	Electromagnetic Waves and Radiating Systems"			
	Author	E.C Jordan & K.G. Balmain,			
	Publisher	Prentice Hall India			
	Edition	2nd Edition			
Course Contents	**UNIT I: Vector Analysis and Maxwell's Equations** Review of vector calculus: Gradient, Divergence, and Curl. Coordinate systems: Cartesian, Cylindrical, and Spherical. Electrostatic fields, Gauss's law, Electric potential and capacitance, Magnetostatic fields, Ampere's circuital law, Maxwell's equations in integral and differential forms.				**9**
	UNIT II: Electromagnetic Wave Theory Wave equation derivation, Uniform plane wave propagation, Wave propagation in free space, Propagation in conducting and dielectric media, Polarization of EM waves, Reflection and transmission at normal and oblique incidence, Poynting theorem, Skin depth and attenuation.				**9**
	UNIT III: Transmission Lines and Waveguides Transmission line equations, Smith chart applications, Impedance matching techniques, Standing wave ratio (SWR), Waveguides: Rectangular waveguide, Circular waveguide. TE, TM, and TEM modes, Cavity resonators, Microwave propagation concepts.				**9**
	UNIT IV: Advanced Electromagnetic Applications Radiation and antennas, Electromagnetic interference (EMI) and compatibility (EMC), Computational electromagnetic, Finite Element Method (FEM), Finite Difference Time Domain (FDTD), Electromagnetic shielding, Metamaterials and advanced EM structures, Applications in radar, satellite, and wireless communication, Recent advances in electromagnetic engineering.				**9**

Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%

Course Code: EC 5156	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory		
Course Title	Antenna Systems for Mobile Communications **(EC 5156)**		
Course Objectives	• To introduce the basic concepts and characteristics of antennas used in mobile communication applications. • To develop understanding of compact, multiband, and advanced antenna design techniques for wireless devices. • To provide knowledge of modern mobile antenna technologies, measurement methods, and practical applications in 4G/5G and IoT systems.		

Course Outcomes		**Cognitive Levels**
CO1	Understand the fundamental principles, parameters, and types of antennas used in mobile communication systems.	Knowledge/Comprehension (Level I/Level-II)
CO2	Analyze microstrip, compact, and multiband antennas suitable for mobile and wireless devices.	Analysis (Level-IV)
CO3	Apply advanced antenna technologies such as MIMO, beam forming, and polarization techniques in modern communication systems.	Application (Level-III)
CO4	Evaluate antenna performance through measurement, simulation, and practical mobile application analysis.	Synthesis/Evaluation (Level-VI/Level-V)

Semester	**I**		**Summer**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Antenna and Wave Propagation (EC 3603)				

Text Books		
1.	Title	Antenna Theory
	Author	C.A. Balanis
	Publisher	Wiley
	Edition	Reprint, 2003.
2.	Title	Antennas
	Author	John D. Kraus and Ronalatory Markefka

	Publisher	MacMillan	
	Edition	3rd Edition	
Reference Books			
1.	Title	Aantennas and Radio Propagation	
	Author	R.E. Collins	
	Publisher	McGraw-Hill	
	Edition	2nd Edition	
Course Contents	**UNIT I: Fundamentals of Mobile Antennas** Introduction to antennas for mobile communication, Basic antenna parameters, Radiation pattern, Gain, Directivity, Bandwidth, Polarization, VSWR and return loss, Radiation mechanism, Frequency bands used in mobile communication, Types of mobile antennas, Monopole antenna, Dipole antenna, Helical antenna, Microstrip patch antenna.		**9**
	UNIT II: Microstrip and Compact Antennas for Mobile Devices Microstrip antenna fundamentals, Feeding techniques, Microstrip line feed, Coaxial feed, Aperture coupling, Proximity coupling, Compact and miniaturized antennas, Multiband and wideband antennas, Planar inverted-F antenna (PIFA), Slot antennas for mobile applications, Antenna substrate materials.		**9**
	UNIT III: Advanced Mobile Antenna Technologies MIMO antenna systems, Diversity techniques, circularly polarized antennas, Beamforming concepts, 4G and 5G mobile antennas, Millimeter-wave antennas, Mutual coupling reduction techniques, SAR (Specific Absorption Rate) analysis.		**9**
	UNIT IV: Antenna Measurement and Applications Antenna measurement techniques, Radiation pattern measurement, Gain and efficiency measurement, Network analyzer basics, Mobile handset antenna design considerations, Antennas for IoT and wearable devices, Antenna simulation tools, HFSS, CST, Recent trends in mobile antenna research.		**9**
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: EC 5157	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	Y	N	N
Type of Course	Theory		
Course Title	Electromagnetic Interference **(EC 5157)**		
Course Objectives	• To introduce the basic concepts of EMI/EMC, interference mechanisms, and electromagnetic noise sources.		

	• To develop understanding of EMI measurement, analysis, and suppression techniques used in electronic and communication systems. • To provide knowledge of EMI/EMC standards and practical applications in modern electronic devices and wireless technologies.				
Course Outcomes					**Cognitive Levels**
CO1	Understand the fundamentals of Electromagnetic Interference (EMI), Electromagnetic Compatibility (EMC), and various interference sources and coupling mechanisms.				Knowledge/Comprehension (Level I/Level-II)
CO2	Analyze EMI measurement techniques, grounding methods, shielding effectiveness, and noise characterization in electronic systems.				Analysis (Level-IV)
CO3	Apply EMI suppression and control techniques such as filtering, shielding, PCB layout design, and cable management for reducing electromagnetic noise.				Application (Level-III)
CO4	Evaluate EMI/EMC standards and investigate practical EMI problems in communication, medical, automotive, and wireless systems.				Synthesis/Evaluation (Level-VI/Level-V)
Semester	**I**			**Summer**	
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Antenna and Wave Propagation (EC 3603)				
Text Books					
1.	Title	Antenna Theory			
	Author	C.A. Balanis			
	Publisher	Wiley			
	Edition	Reprint, 2003.			
2.	Title	Antennas			
	Author	John D. Kraus and Ronalatory Markefka			
	Publisher	MacMillan			
	Edition	3rd Edition			
Reference Books					
1.	Title	Aantennas and Radio Propagation			
	Author	R.E. Collins			
	Publisher	McGraw-Hill			
	Edition	2nd Edition			
Course Contents	**UNIT I: Fundamentals of Electromagnetic Interference** Introduction to Electromagnetic Interference (EMI), Sources of EMI, Natural and man-made noise sources, Electromagnetic compatibility (EMC), Types				**9**

	of EMI, Conducted EMI, Radiated EMI, Coupling mechanisms, Capacitive coupling, Inductive coupling, Radiative coupling Frequency spectrum of interference, EMI standards and regulations.	
	UNIT II: EMI Analysis and Measurement Techniques EMI measurement instruments, Spectrum analyzer, EMI receiver, LISN (Line Impedance Stabilization Network), Noise measurement techniques, Time-domain and frequency-domain analysis, Near-field and far-field measurements, Shielding effectiveness measurement, Grounding and bonding concepts, Signal integrity and noise analysis.	**9**
	UNIT III: EMI Control and Suppression Techniques Shielding techniques, Electric shielding, Magnetic shielding, Grounding methods, Filtering techniques, Low-pass filters, High-pass filters, EMI filters, PCB layout considerations for EMI reduction, Cable shielding and routing, Noise suppression methods, Ferrite beads and chokes.	**9**
	UNIT IV: Applications and Standards of EMI/EMC EMC standards and regulations, FCC, CISPR, IEC standards, EMI in communication systems, EMI in antennas and wireless devices, EMI in medical electronics, Automotive EMI/EMC, Aerospace and defense applications, Case studies of EMI problems, Recent trends in EMI/EMC research.	**9**
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%

Course Code: EC 5158	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory		
Course Title	Principle of Microwave solid state devices **(EC 5158)**		
Course Objectives	• To introduce the basic principles of microwave solid-state devices and semiconductor physics. • To develop understanding of microwave diodes, oscillators, transistors, and amplifier technologies. • To provide knowledge of modern microwave devices and their applications in communication and radar systems.		

Course Outcomes		**Cognitive Levels**
CO1	Understand the fundamentals of semiconductor physics and microwave solid-state device principles.	Knowledge/Comprehension (Level I/Level-II)
CO2	Analyze the characteristics and operation of microwave diodes and oscillator devices.	Analysis (Level-IV)
CO3	Apply microwave transistor and amplifier concepts for high-frequency communication systems.	Application (Level-III)

CO4	Evaluate modern microwave solid-state devices and their applications in radar, satellite, and wireless communication systems.	Synthesis/Evaluation (Level-VI/Level-V)

Semester	**I**		**Summer**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	RF and Microwave Engineering (EC 4701)				

Text Books		
1.	Title	Microwave Device and Circuits
	Author	Samuel Y. Liao
	Publisher	PHI
	Edition	3rd Reprint, 2003.
2.	Title	Microwave Semiconductor Device
	Author	SK Roy, M Mitra
	Publisher	PHI
	Edition	2003
Reference Books		
1.	Title	Microwave Engineering
	Author	David M. Pozar
	Publisher	Wiley
	Edition	4th

Course Contents	**UNIT I:** Fundamentals of Microwave Solid-State Devices Introduction to microwave engineering, Microwave frequency spectrum and applications, Semiconductor physics review, Energy band theory, Charge carriers in semiconductors, Drift and diffusion currents, Junction diode characteristics, Microwave semiconductor materials, Negative resistance concept, Transferred electron effect.	**9**
	UNIT II: Microwave Diodes and Oscillators Schottky diode, Varactor diode, PIN diode, Tunnel diode, Gunn diode: Principle of operation, Modes of operation, Gunn oscillator IMPATT diode, TRAPATT diode, BARITT diode, Microwave oscillator circuits.	**9**
	UNIT III: Microwave Transistors and Amplifiers Bipolar Junction Transistor (BJT) at microwave frequencies, Field Effect Transistor (FET), MESFET, HEMT, Microwave transistor amplifiers, Power amplifiers, Low-noise amplifiers (LNA), Stability considerations, Microwave integrated circuits (MIC).	**9**
	UNIT IV: Applications and Modern Microwave Devices	**9**

	Microwave mixers and detectors, Frequency multipliers, Microwave switches and phase shifters, Monolithic Microwave Integrated Circuits (MMIC), Microwave photonic devices, Solid-state microwave sources, Applications in radar, satellite, and wireless communication, Recent advances in microwave solid-state devices.	
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%

Course Code: EC 5159	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	Y	N	Y
Type of Course	Theory		
Course Title	5G Massive MIMO: Principles, Architecture and Applications **(EC 5159)**		
Course Objectives	• Understand the fundamentals of 5G wireless communication systems and the principles, architecture, and operational concepts of Massive MIMO technology. • •Analyze the design aspects, signal processing techniques, channel characteristics, and performance metrics associated with Massive MIMO systems in modern wireless networks. • Explore practical applications, implementation challenges, and emerging trends of Massive MIMO in advanced communication systems such as 5G/6G, IoT, smart cities, and high-capacity wireless networks.		

Course Outcomes		**Cognitive Levels**
CO1	Explain the principles, evolution, and significance of Massive MIMO in 5G wireless communication systems.	Knowledge/Comprehension (Level I/Level-II)
CO2	Analyze the architecture, antenna configurations, beamforming techniques, and channel characteristics of Massive MIMO systems.	Analysis (Level-IV)
CO3	Evaluate the performance of Massive MIMO systems using signal processing techniques, channel estimation, and interference management methods.	Application (Level-III)
CO4	Apply Massive MIMO concepts to modern 5G applications and identify emerging research challenges and future trends in next-generation wireless networks.	Synthesis/Evaluation (Level-VI/Level-V)

Semester	**I**	**Summer**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36

Prerequisite course codes with course names	Antenna and Wave Propagation **(EC 3603)**		
Text Books			
1.	Title	Fundamentals of Massive MIMO	
	Author	Thomas L. Marzetta	
	Publisher	Cambridge University Press.	
	Edition	1st , 2016	
2.	Title	5G NR: *The Next Generation Wireless Access*	
	Author	Erik Dahlman	
	Publisher	Academic Press.	
	Edition	2nd , 2018	
Reference Books			
1.	Title	*Millimeter Wave Wireless Communications*	
	Author	Theodore S. Rappaport	
	Publisher	Pearson.	
	Edition	2nd , 2015	
Course Contents	**UNIT 1: Fundamentals of 5G and Massive MIMO** Evolution of wireless communication systems, Introduction to 5G networks and requirements, Basics of MIMO communication systems, Concept and advantages of Massive MIMO, Spectral efficiency and energy efficiency, Channel characteristics in Massive MIMO systems.		**9**
	UNIT II: Massive MIMO Architecture and Design Massive MIMO system architecture, Antenna array configurations, Beamforming techniques and precoding methods, Hybrid beamforming architecture, Channel estimation techniques, Pilot contamination and mitigation methods, Uplink and downlink transmission in Massive MIMO, Hardware implementation challenges.		**9**
	UNIT III: Signal Processing and Performance Analysis Linear detection techniques: ZF, MMSE, and MRC, Spatial multiplexing and diversity techniques, Capacity and throughput analysis, Interference management in Massive MIMO, Energy-efficient communication techniques, Millimeter-wave (mmWave) Massive MIMO systems, Performance evaluation metrics and simulations.		**9**
	UNIT IV: Applications and Emerging Trends Massive MIMO in 5G NR networks, Applications in smart cities and IoT, Massive MIMO for autonomous vehicles and Industry 4.0, Machine learning applications in Massive MIMO, Cell-free Massive MIMO systems,		**9**

	Integration with RIS and beam management, Challenges and future directions toward 6G networks, challenges in rural and urban areas, 6G overview and future trends, Research directions in next-generation wireless systems.	
Course Assessment	Total Marks =100 Theory (75 Marks)	Evaluation will be done for 100 marks and 75% of the marks secured will be considered.
	Practical (25 Marks) Evaluation will be done for 50 marks and 50% of the marks secured will be considered.	Continuous Evaluation 20% Laboratory Examination 50% Viva Voce 30%

2nd Semester

Course Code: EC 5201	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory		
Course Title	**Image processing Techniques (EC5201)**		
Course Objectives	• Image processing is the basis of all digital media technology and is an active area of research over a wide range of applications such as compression and medical image analysis. • The course features an introduction to digital image processing algorithms that form the core of digital media technology.		

Course Outcomes		**Cognitive Levels**
CO1	Understand and apply the fundamentals of image processing techniques.	Knowledge/Comprehension (Level I/Level-II)
CO2	Apply enhancement, segmentation and compression techniques to 2D images.	Analysis (Level-IV)
CO3	Analyze and represent an image using transform techniques.	Application (Level-III)
CO4	Interpret image in various data formats by applying image transformation processing techniques for different applications.	Synthesis/Evaluation (Level-VI/Level-V)

Semester	**II**	**Winter**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Signals and Systems (EC2301), Digital Signal Processing (EC2404)				

Text Books			
1.	Title	Digital Image Processing	
	Author	Rafael E. Gonzaleze and Richard E. Woods,	
	Publisher	Pearson, 2018.	
	Edition	4th edition	
2.	Title	Fundamentals of Digital Image Processing, 2002.	
	Author	Anil K. Jain	
	Publisher	Prentice Hall of India	
	Edition	2nd ed. New York, NY: 2006.	
Reference Books			
1.	Title	The Image Processing Handbook	
	Author	J. C. Russ.	
	Publisher	McGraw Hill	
	Edition	4th edn., 2002	
Course Contents	**UNIT-1** **FUNDAMENTALS:** Basic steps of image processing system, Sampling and quantization of an Image, Basic relationship between pixels, Image Transforms - 2D Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT).		**9**
	UNIT-2 **IMAGE ENHANCEMENT:** Spatial domain methods: Point processing- Intensity transformations, Histogram processing, Image subtraction, Image averaging. Spatial filtering- Smoothing filters, Sharpening filters. Frequency domain methods: Low pass filtering, High pass filtering, Homomorphic filter.		**9**
	UNIT-3 **IMAGE SEGMENTATION:** Point Detection, Line Detection, Edge Detection using Gradient and Laplacian Filters, Hough Transform, Thresholding: Global, Local and Adaptive, Region Based Segmentation: Region Growing Algorithm, Region Split and Merge Algorithm.		**9**
	UNIT-4 **REPRESENTATION, DESCRIPTION AND RECOGNITION:** Representation- chain codes, polygonal approximation and skeletons, Boundary descriptors-simple descriptors, shape numbers, Regional descriptors-simple. Recognition: Pattern and Pattern classes.		**9**
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: **EC 5202**	Open Elective Course: (Y/N)	Departmental Core Course: (Y/N)	Departmental Elective Course: (Y/N)

Department of Electronics & Communication Engineering
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(An Autonomous Institute under MHRD, Govt. of India)

	N		Y		N
Type of Course	Theory				
Course Title & Code	Modern Digital Communication Techniques (EC 5202)				
Course Objectives	• To provide fundamental understanding of analog-to-digital conversion techniques and digital representation of signals used in modern communication systems. • To study various digital modulation and demodulation techniques along with their performance characteristics in digital communication channels. • To analyze data transmission systems, probability of error, matched filter receivers, and coherent/non-coherent detection methods for reliable communication. • To introduce concepts of information theory, channel capacity, source and channel coding techniques, and their importance in error detection and correction for efficient digital communication systems.				
Course Outcomes					Cognitive Levels
CO1	Understanding Concepts of Data Conversions				Knowledge/Comprehension (Level I/Level-II)
CO2	Learning Digital Modulations and data transmissions				Application (Level-III)
CO3	Analyze concepts of Information content.				Analysis (Level-IV)
CO4	Have concept of coding and its importance.				Synthesis/Evaluation (Level-VI/Level-V)
Semester	**II**			**Winter**	
Contact Hours	Lecture	Tutorial	Practical	Credits	Total Teaching Hours
	3	1	0	4	48
Prerequisite course codes with course names	Analog Communication; Digital Communication;				
Text Books					
1.	Title	Digital Communication			
	Author	S. Haykin			
	Publisher	Wiley			
	Edition	2006 or Latest			
2.	Title	Principles of Communication Systems			
	Author	Taub and Schilling			
	Publisher	TMH			
	Edition	2nd 2006 or Latest			
Reference Books					
1.	Title	Digital Communications: Fundamentals & Applications			

	Author	Sklar & Ray	
	Publisher	Pearson	
	Edition	2nd Edition 2009 or Latest	
Course Contents	UNIT I: Analog-to-Digital Conversion: Sampling theorem, Pulse-Amplitude Modulation, Channel bandwidth for PAM signal, Natural sampling, Flat top sampling, Quantization of signals, Quantization error, Pulse- code modulation (PCM), Electrical representation of binary digits, The PCM system, Companding, Multiplexing PCM signals, Differential PCM, Delta modulation, Adaptive delta modulation, Vocoders, Channel Vocoder, Linear Predictive coder.		12
	UNIT II: Digital Modulation Techniques: Binary Phase-Shift Keying (BPSK), Differential Phase-Shift Keying, Differentially-Encoded PSK (DEPSK), Quadrature Phase-Shift Keying (QPSK), Quadrature Amplitude Shift Keying (QASK), Binary Frequency-Shift Keying (BFSK), Similarity of BPSK and BFSK, M-ary FSK, Minimum Shift Keying (MSK).		12
	UNIT III: Data Transmission: A base band signal receiver, Probability of error, The Optimum Filter, Matched Filter, Probability of error in Matched filter, Coherent reception, Coherent reception of PSK and FSK, Non-Coherent reception of FSK, PSK and QPSK, Calculation of error probability of BPSK and BFSK, Error probability for QPSK] Bit-by-bit encoding versus Symbol-by-Symbol encoding, Relationship between Bit error rate and Symbol Error rate and comparison of modulation systems.		12
	UNIT IV: Information Theory and Coding: Discrete messages, The concept of amount of information, Entropy, Information rate, Coding to increase average information per bit, Shannon's theorem, Capacity of a Gaussian channel, Bandwidth-S/N tradeoff, use of orthogonal signals to attain Shannon's limit, Efficiency of orthogonal signal transmission, Coding: Parity check bit coding for error detection, Coding for error detection and error correction, Block codes (coding and decoding), Convolution codes (coding and decoding).		12
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: EC 5203	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory		
Course Title	Microwave and Terahertz Engineering **(EC 5203)**		
Course Objectives	• To provide fundamental understanding of microwave engineering principles and microwave transmission structures. • To study microwave passive devices, resonators, and microwave circuit components used in high-frequency systems. • To analyze microwave antennas, feed systems, and microwave integrated circuits (MICs).		

	• To understand microwave noise, nonlinear distortion, and practical microwave system implementation techniques.	
Course Outcomes		**Cognitive Levels**
CO1	Understand Maxwell's equations, transmission line theory, microwave propagation, and basic microwave devices.	Knowledge/Comprehension (Level-I/Level-II)
CO2	Analyze microwave transmission structures and microwave components for different frequency band applications.	Analysis (Level-IV)
CO3	Explain the operating principles and performance characteristics of microwave devices, antennas, and microwave integrated circuits.	Analysis/Application (Level-IV/Level-III)
CO4	Design and implement microwave circuits and systems considering matching, noise, nonlinear distortion, and practical application constraints.	Application/Synthesis (Level-III/Level-VI)

Semester	**II**		**Winter**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	1	0	3	48
Prerequisite course codes with course names	Electromagnetic Theory Microwave Engineering Antennas and Wave Propagation				

Text Books		
1.	Title	RF Microelectronics
	Author	B. Razavi
	Publisher	IEEE Press
	Edition	1995
2.	Title	Microwave Engineering
	Author	D. M. Pozar
	Publisher	Wiley
	Edition	4th Edition, 2012
3.	Title	Elements of Electromagnetics
	Author	Matthew N. O. Sadiku
	Publisher	Oxford University Press
	Edition	4th Edition
4.	Title	Engineering Electromagnetics
	Author	Nathan Ida
	Publisher	Springer India
	Edition	2nd Edition
Reference Books		
1.	Title	Foundations for Microwave Engineering
	Author	Robert E. Collin

	Publisher	Wiley-IEEE Press	
	Edition	2nd Edition	
2.	Title	Microwave Devices and Circuits	
	Author	Samuel Y. Liao	
	Publisher	Pearson Education	
	Edition	3rd Edition	
3.	Title	Antennas and Wave Propagation	
	Author	C. A. Balanis	
	Publisher	Wiley	
	Edition	3rd Edition	
Course Contents	**UNIT I: Electromagnetic Foundations and Transmission Line** Significance of Maxwell equations in microwave engineering; electromagnetic wave propagation; theory of transmission lines; transmission line equations and parameters; reflection coefficient and standing wave ratio; impedance matching techniques; principles of microwave circuits; microwave frequency spectrum and applications.		**12**
	UNIT II: Waveguides and Microwave Passive Components Waveguides and boundary conditions; TE, TM, and TEM modes; rectangular and circular waveguides; cavity resonators and resonant frequencies; directional couplers; phase shifters; microwave junctions and tees; microstrip lines and transmission characteristics; microwave passive circuit analysis for different frequency bands.		**12**
	UNIT III: Microwave Antennas, Feed Systems and MICs Various types of microwave antennas and feed systems; horn antennas, parabolic reflectors, microstrip antennas, and array antennas; antenna measurement principles and parameters; microwave integrated circuits (MICs); microwave packaging concepts; stub matching techniques; Smith chart applications in microwave circuit design and impedance matching.		**12**
	UNIT IV: Microwave Noise, Distortion and System Applications Noise in microwave circuits; noise figure and noise temperature; nonlinear distortion in microwave systems; intermodulation distortion and harmonic generation; dynamic range analysis; microwave system implementation considerations; practical microwave devices and applications in radar, satellite communication, wireless communication, and RF systems.		**12**
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code:	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
EC 5204	N	Y	N

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Type of Course	Theory				
Course Title	**Communication Networks (5204)**				
Course Objectives	• This course introduces the fundamentals of computer communication networks, including network architecture, data link layer protocols, routing, wireless LANs, congestion control, and TCP/IP internetworking. • It covers network performance analysis, MAC protocols, transport layer protocols, QoS, and socket programming for client-server communication, providing both theoretical and practical understanding of modern networking technologies.				
Course Outcomes					**Cognitive Levels**
CO1	Explain computer network architecture, switching, and data link layer protocols.				Knowledge/Comprehension (Level I/Level-II)
CO2	Analyze network performance using queuing models and MAC protocols.				Analysis (Level-IV)
CO3	Apply routing, transport, and congestion control mechanisms in packet networks.				Application (Level-III)
CO4	Develop client-server applications using TCP/IP and socket programming.				Synthesis/Evaluation (Level-VI/Level-V)
Semester	**II**			**Winter**	
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Digital Communication fundamentals (EC2402), Probability and Random Processes, (MA 2401)				
Text Books					
1.	Title	Communication Networks			
	Author	A. Leon-Garcia and I. Widjaja,			
	Publisher	McGraw-Hill, 2009			
	Edition	2nd Ed			
2.	Title	Communication Networking: An Analytical Approach			
	Author	A. Kumar, D. Manjunath and J. Kuri,			
	Publisher	Elsevier, 2004			
	Edition	2nd ed. 2004.			
Reference Books					
1.	Title	Computer Networks: A Systems Approach,			
	Author	L. Peterson and B. Davies			
	Publisher	Elsevier, 2007			
	Edition	4th Ed			

Course Contents	**Unit-1** Introduction to Computer Networks -Store-and-forward and circuit switching, layered network architecture, the OSI network model, Internet architecture; Data Link Layer and Peer to Peer protocols - Encoding (NRZ, NRZI, Manchester, 4B/5B), HDLC, Error detection, ARQ - SW, GBN, SR;	**9**
	Unit-2 Delay models in Data Networks-Traffic multiplexing on a communication link, little's theorem, The M/M/1 Queueing System, M/G/I Queues with Vacations, Priority Queues; MAC protocols and LAN- Polling and Reservations, ALOHA, Slotted ALOHA, CSMA-CD, Ethernet and IEEE 802.3,	**9**
	Unit-3 Wireless LAN and IEEE 802.11. Routing in packet networks-IP, shortest-path routing, intra- domain routing (OSPF, RIP), inter-domain routing (BGP), routing for mobile hosts; End-to-End Protocols- UDP and TCP;	**9**
	Unit-4 Congestion Control and Resource Allocation -Resource Allocation, TCP Congestion Control, Congestion-avoidance mechanisms, QoS; Internetworking using TCP/IP - Network programming using socket API, client/server communication.	**9**
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%

Course Code: **EC 5251**	Open Elective Course: (Y/N)	Departmental Core Course: (Y/N)	Departmental Elective Course: (Y/N)
	N	Y	Y
Type of Course	Theory		
Course Title & Code	**Data Communication (EC 5251)**		
Course Objectives	• To provide fundamental knowledge of data communication systems, networking concepts, layered architectures, and communication protocols. • To understand the operation of physical, data link, network, transport, session, presentation, and application layers in computer networks. • To study routing algorithms, congestion control techniques, error control mechanisms, and medium access protocols used in modern communication networks. • To introduce network applications, data compression, cryptography concepts, and security issues in data communication and networking systems.		
Course Outcomes			Cognitive Levels

CO1	Understand the issues and challenges at all levels of abstraction in the architecture of a computer network.	Knowledge/Comprehension (Level I/Level-II)
CO2	Understand how to Develop networked applications	Application (Level-III)
CO3	Realize protocols at different layers of a network hierarchy.	Analysis (Level-IV)
CO4	Recognize network security issues and be able to design/code for certain properties	Synthesis/Evaluation (Level-VI/Level-V)

Semester	VI	WinterWi			
Contact Hours	Lecture	Tutorial	Practical	Credits	Total Teaching Hours
	3	0	0	3	36
Prerequisite course codes with course names	Analog Communication; Digital Communication;				

Text Books		
1.	Title	Introduction to Data communications and Networking
	Author	Wayne Tomasi
	Publisher	Pearson
	Edition	2007 or Latest
2.	Title	Data and Computer Communications
	Author	Stallings W
	Publisher	PHI
	Edition	6th or Latest

Reference Books		
1.	Title	TCP/IP Protocol Suit
	Author	Behrouz A. Forouzan
	Publisher	TMH
	Edition	2000 or Latest

Course Contents	UNIT I: Review of data communication techniques, basic networking concepts, layered network and protocol concepts, quality of service, Network structure, Hierarchies, The OSI reference model, Service Primitives, Example Networks : ARPANET, SNA etc.	9
	UNIT II: The Physical Layer: Transmission Media, Transmission and Switching, Terminal, The medium Access sub layer, The ALOHA protocols, LAN Protocols, Ethernet, Token bus, Token ring. The Data link layer: Design issues, Error control, Sliding Window Protocols, protocols performance.	9
	UNIT III: The Network layer: Design issues, Routing algorithms, congestion control Algorithms, Internet working.	9

	UNIT IV: The Transport layer: Design issues, connection management. The Session layer: Design issues, Remote procedure call. The Presentation layer: Design issues, data compression techniques concepts, Introduction to Cryptography. The Application layer: Design issues, File transfer, Access and management, Virtual terminals.	9
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%

Course Code: **EC 5252**	Open Elective Course: (Y/N)	Departmental Core Course: (Y/N)	Departmental Elective Course: (Y/N)
	N	Y	Y
Type of Course	Theory		
Course Title & Code	**Satellite Communication (EC 5252)**		
Course Objectives	• To provide fundamental knowledge of satellite communication systems, orbital mechanics, satellite launch techniques, and satellite frequency bands. • To understand spacecraft subsystems, satellite link design, and the application of analog and digital modulation techniques in satellite communication networks. • To study multiplexing and multiple access techniques, satellite uplink/downlink analysis, and power budget calculations for reliable satellite communication. • To introduce error control coding, satellite earth station technologies, VSAT systems, direct broadcast satellites, and modern satellite communication applications.		

Course Outcomes		Cognitive Levels
CO1	Understand the concept of orbital mechanics and launch methodologies.	Knowledge/Comprehension (Level I/Level-II)
CO2	Understand how analog and digital technologies are used for satellite communication networks.	Application (Level-III)
CO3	Design link power budget for satellites.	Analysis (Level-IV)
CO4	Understand the design of Earth station and tracking of the satellites.	Synthesis/Evaluation (Level-VI/Level-V)

Semester	II	Winter			
Contact Hours	Lecture	Tutorial	Practical	Credits	Total Teaching Hours
	3	0	0	3	36
Prerequisite course codes with course names	Analog Communication; Digital Communication; Modern Wireless Communication (EC 5103)				
Text Books					

1.	Title	Satellite communication	
	Author	Timothy Pratt, Charles W. Bostian	
	Publisher	John Wiley & sons, Publication	
	Edition	2003 or Latest	
2.	Title	Digital Communication by satellite	
	Author	J.J. Spilker	
	Publisher	PHI Publication	
	Edition	1997 or Latest	
Reference Books			
1.	Title	Communication satellite systems	
	Author	J. Martin	
	Publisher	PHI Publication	
	Edition	2001 or Latest	
Course Contents	UNIT I: Origin and brief history of satellite communications, an overview of satellite system engineering, satellite frequency bands for communication. Orbital theory: Orbital mechanics, locating the satellite in the orbit w.r.t. earth look angle determination. Azimuth & elevation calculations.		9
	UNIT II: Spacecraft systems: Attitude and orbit control system, telemetry, tracking and command (TT&C), communications subsystems, transponders, spacecraft antennas. Satellite link design: Basic transmission theory, noise figure and noise temperature, C/N ratio, satellite down link design, satellite uplink design		9
	UNIT III: Modulation, Multiplexing, Multiple access Techniques: Analog telephone transmission, Fm theory, FM Detector theory, analog TV transmission, S/N ratio Calculation for satellite TV linking, Digital transmission, base band and band pass transmission of digital data, BPSK, QPSK, FDM, TDM, Access techniques: FDMA, TDMA, CDMA		9
	UNIT IV: Encoding & FEC for Digital satellite links: Channel capacity, error detection coding, linear block, binary cyclic codes, and convolution codes. Satellite Systems: Satellite Earth station Technology, satellite mobile communication, VSAT technology, Direct Broadcast by satellite (DBS)		9
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: EC 5253	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory		

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Course Title	**Advance Radio Communication (EC5253)**				
Course Objectives	• To introduce advanced concepts of radio and wireless communication systems, and to understand wireless propagation models and channel impairments. • To study modern digital modulation and multiple access techniques and to analyze cellular communication systems and emerging wireless technologies. To explore next-generation communication systems including 5G, 6G, SDR, cognitive radio, and IoT networks.				
Course Outcomes					**Cognitive Levels**
CO1	Explain the principles of advanced radio propagation and wireless channel behaviour.				Knowledge/Comprehension (Level I/Level-II)
CO2	Analyse modern digital modulation and multiple access techniques used in wireless communication systems.				Analysis (Level-IV)
CO3	Evaluate the performance of cellular, broadband, and MIMO-based radio communication systems.				Application (Level-III)
CO4	Apply advanced radio technologies such as OFDM, SDR, and cognitive radio in modern wireless networks.				Synthesis/Evaluation (Level-VI/Level-V)
Semester	**II**			**Winter**	
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Signals and Systems (EC2301), Analog Communication (EC2302)				
Text Books					
1.	Title	Wireless Communications: Principles and Practice,			
	Author	Theodore S. Rappaport,			
	Publisher	Pearson.			
	Edition	6th Edition			
2.	Title	Wireless Communications,			
	Author	Andrea Goldsmith			
	Publisher	Cambridge University Press.			
	Edition	6th Edition			
Reference Books					
1.	Title	Fundamentals of Wireless Communication			
	Author	David Tse and Pramod Viswanath			
	Publisher	Cambridge University Press.			
	Edition	5th edition			

Course Contents	**UNIT 1** Evolution of radio communication systems, electromagnetic spectrum and radio frequency bands, wireless communication architecture, radio transmission fundamentals, free-space propagation model, path loss and shadowing, multipath propagation, delay spread and Doppler spread, small-scale and large-scale fading, Rayleigh and Rician fading models, channel capacity, diversity techniques, and link budget analysis.	**9**
	UNIT 2 ASK, FSK, PSK, QPSK, QAM, OFDM principles and applications, spread spectrum techniques, error control coding, adaptive modulation techniques, FDMA, TDMA, CDMA, and OFDMA multiple access techniques	**9**
	UNIT 3 Cellular concept and frequency reuse, handoff and roaming, GSM architecture, LTE and 5G overview, radio resource management, power control and interference management, MIMO communication systems, smart antennas and beamforming, software defined radio (SDR), cognitive radio networks, wireless sensor networks, ad hoc networks, and Internet of Things (IoT) communication.	**9**
	UNIT 4 Millimetre wave communication, massive MIMO, 6G communication overview, AI/ML in wireless communication, satellite communication systems, UAV communication systems, and green communication technologies.	**9**
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%

Course Code: EC 5254	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory		
Course Title	**Microwave Devices and Circuits (EC 5255)**		
Course Objectives	• To provide knowledge of microwave frequency analysis and electromagnetic wave propagation principles. • To study microwave transmission lines, waveguides, and passive microwave components. • To understand the operation and characteristics of active microwave semiconductor devices. • To develop skills in microwave circuit analysis, impedance matching, and communication link design.		
Course Outcomes			**Cognitive Levels**

CO1	Understand microwave analysis methods, electromagnetic wave propagation, and microwave transmission principles.	Knowledge/Comprehension (Level-I/Level-II)
CO2	Apply microwave analysis methods to determine the characteristics of passive and active microwave devices and circuits.	Application (Level-III)
CO3	Analyse microwave circuits and systems using transmission line theory, waveguide analysis, and Smith chart techniques.	Analysis (Level-IV)
CO4	Design and evaluate microwave communication links, impedance matching networks, and microwave filter circuits for practical applications.	Application/Evaluation (Level-III/Level-V)

Semester	**II**			**Winter**	
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Electromagnetic Theory Microwave Engineering Electronic Devices and Circuits				

Text Books		
1.	Title	Microwave Devices and Circuits
	Author	Samuel Y. Liao
	Publisher	PHI
	Edition	3rd Edition
2.	Title	Microwave Semiconductor Devices
	Author	S. K. Roy and M. Mitra
	Publisher	PHI
	Edition	2003
3.	Title	Microwave Engineering
	Author	David M. Pozar
	Publisher	Wiley
	Edition	4th Edition
Reference Books		
1.	Title	Foundations for Microwave Engineering
	Author	Robert E. Collin
	Publisher	Wiley-IEEE Press
	Edition	2nd Edition
2.	Title	RF Microelectronics
	Author	Behzad Razavi
	Publisher	Pearson
	Edition	2nd Edition
3.	Title	Microwave Transistor Amplifiers

	Author	Guillermo Gonzalez	
	Publisher	Prentice Hall	
	Edition	2nd Edition	
Course Contents	**UNIT I: Electromagnetic Waves and Microwave Transmission Principles** Microwave frequencies and applications; interactions between electrons and electromagnetic fields; electromagnetic plane waves; electric and magnetic wave equations; Poynting theorem; uniform plane waves and reflection; plane wave propagation in free space and lossless dielectric media; propagation in lossy media and metallic film coatings on plastic substrates.		**9**
	UNIT II: Transmission Lines, Smith Chart and Microwave Passive Components Transmission line equations and solutions; reflection coefficient and transmission coefficient; standing waves and standing wave ratio (SWR); line impedance and admittance; Smith chart and impedance matching techniques; microwave waveguides and components; rectangular waveguides; microwave cavities; directional couplers; circulators and isolators.		**9**
	UNIT III: Microwave Semiconductor Devices and Circuit Modeling Microwave transistors and tunnel diodes; microwave bipolar transistors; heterojunction transistors; microwave tunnel diodes; microwave field-effect transistors; junction field-effect transistors (JFETs); metal-semiconductor field-effect transistors (MESFETs); microwave device modeling and performance characterization; microwave circuit analysis using equivalent circuit models.		**9**
	UNIT IV: Microwave Circuit Design and Communication Applications Microwave communication link concepts; impedance matching networks; microwave filter circuits; microwave amplifier concepts; design considerations for microwave systems; microwave circuit performance evaluation; practical applications in radar, satellite communication, wireless communication, and RF systems.		**9**
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: EC 5255	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory		
Course Title	**RF Components and Circuit Design (EC5256)**		

Course Objectives	• This course covers the fundamentals of RF and wireless communication systems, RF receiver and transmitter architectures, high-frequency device behavior, and RF circuit design. • It includes the design of RF building blocks such as LNAs, mixers, oscillators, PLLs, and power amplifiers, along with RF VLSI implementation and CAD tools. To Various array design methods and direction of arrival estimation techniques are discussed in this course.

Course Outcomes		**Cognitive Levels**
CO1	Explain RF and wireless communication fundamentals, modulation techniques, and multiple access methods.	Knowledge/Comprehension (Level I/Level-II)
CO2	Analyze RF receiver/transmitter architectures and high-frequency device behavior.	Analysis (Level-IV)
CO3	Design RF building blocks such as LNAs, mixers, oscillators, and VCOs.	Application (Level-III)
CO4	Evaluate RF synthesizers, PLLs, power amplifiers, and RF VLSI design techniques.	Synthesis/Evaluation (Level-VI/Level-V)

Semester	**II**	**Winter**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36

Prerequisite course codes with course names	Analog Communication (EC2302), Digital Communication (2402), Analog Electronics Circuits (EC2303)

Text Books		
1.	Title	RF Microelectronics
	Author	Behzad Razavi,
	Publisher	Pearson Education, Inc.
	Edition	2nd Edition, 2012
2.	Title	The Design of CMOS Radio-Frequency Integrated Circuits
	Author	Thomas Lee
	Publisher	Cambridge University Press.
	Edition	2nd Edition, 2004 onwards

Reference Books		
1.	Title	Design of Analog CMOS Integrated Circuits
	Author	Behzad Razavi
	Publisher	McGraw Hill Education
	Edition	Second edition, 2017

	Unit-1: RF and Wireless Communication Fundamentals	**9**

Course Contents	Introduction to RF and wireless technology, RF design challenges, modulation techniques, noise, distortion, sensitivity, dynamic range, coherent/non-coherent detection, and multiple access techniques.	
	Unit-2: RF Receiver and Transmitter Architectures RF receiver and transmitter architectures, RF behaviour of BJT and MOSFET, transistor modelling, noise performance, and high-frequency parasitic effects.	**9**
	Unit-3: RF Building Blocks and Circuit Design RF system blocks and VLSI implementation, LNAs, RF mixers, oscillators, VCOs, phase noise, quadrature, and single-sideband generators.	**9**
	Unit-4: RF Synthesizers and Power Amplifiers RF synthesizers, PLLs, frequency dividers, RF power amplifiers, linearization techniques, RF filters, and CAD tools for RF VLSI design	**9**
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%

Course Code: EC 5256	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory		
Course Title	Radar Engineering **(EC 5257)**		
Course Objectives	• To introduce the fundamental concepts and operational principles of radar systems. • To develop understanding of radar components, signal processing, and target detection techniques. • To provide knowledge of modern radar technologies and their practical applications in communication, defence, and remote sensing systems.		
Course Outcomes			**Cognitive Levels**
CO1	Understand the basic principles, parameters, and operation of radar systems.		Knowledge/Comprehension (Level I/Level-II)
CO2	Analyze radar transmitters, receivers, antennas, and display systems used in radar engineering.		Analysis (Level-IV)
CO3	Apply radar detection, Doppler processing, and target tracking techniques in practical radar systems.		Application (Level-III)
CO4	Evaluate modern radar technologies and their applications in defense, navigation, weather monitoring, and remote sensing.		Synthesis/Evaluation (Level-VI/Level-V)
Semester	**II**	**Winter**	

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Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Antenna and Wave Propagation (EC 3603)				

Text Books		
1.	Title	Introduction Radar Systems
	Author	M.I. Skolnik
	Publisher	McGraw Hill
	Edition	4th, 2001.
2.	Title	Introduction to Radar Systes
	Author	Merrill I. Skolink
	Publisher	TMH
	Edition	2nd 2007
Reference Books		
1.	Title	Microwave and Radar Engineering
	Author	M.L. Sisodia, J.P. Agrawal, V.L. Gupta
	Publisher	Anshan Ltd
	Edition	1st, 2011

Course Contents	**UNIT I: Fundamentals of Radar Systems** Introduction to radar engineering, Basic radar principle, Radar frequency bands, Radar block diagram and operation, Radar range equation, Pulsed radar and CW radar, Radar cross section (RCS), Radar system parameters: Range, Resolution, Accuracy. Maximum unambiguous range.	**9**
	UNIT II: Radar Transmitters, Receivers and Displays Radar transmitters: Magnetron, Klystron, Traveling wave tube (TWT). Radar receivers, Duplexers and mixers, Radar antennas. Display systems: A-scope, B-scope, PPI display. Noise figure and sensitivity, Radar signal processing basics.	**9**
	UNIT III: Radar Detection and Tracking Techniques Detection of radar signals, Probability of detection and false alarm, Moving Target Indicator (MTI) radar, Doppler radar, Pulse compression techniques, Tracking radar systems, Automatic target tracking, Clutter and noise reduction methods.	**9**
	UNIT IV: Modern Radar Applications and Advanced Systems Phased array radar, Synthetic Aperture Radar (SAR), Weather radar, Airborne and marine radar, Radar applications in defense and navigation, Radar in satellite and remote sensing, Modern digital radar systems, Recent trends in radar technology.	**9**

Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%

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Course Code: EC 5257	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory		
Course Title	Advance EM Wave Propagation and Antenna **(EC 5258)**		
Course Objectives	• To introduce advanced concepts of electromagnetic wave propagation and wireless channel behavior. • To develop understanding of advanced antenna structures, array systems, and modern wireless antennas. • To provide knowledge of computational, simulation, and AI-based techniques used in modern antenna engineering.		

Course Outcomes		**Cognitive Levels**
CO1	Understand the principles of electromagnetic wave propagation in different communication environments.	Knowledge/Comprehension (Level I/Level-II)
CO2	Analyze advanced propagation mechanisms and wireless channel characteristics at microwave and millimeter-wave frequencies.	Analysis (Level-IV)
CO3	Apply advanced antenna theories and modern antenna technologies for wireless communication systems.	Application (Level-III)
CO4	Evaluate modern antenna applications, computational techniques, and AI-based antenna design methods.	Synthesis/Evaluation (Level-VI/Level-V)

Semester	**II**	**Winter**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Electromagnetic Theory **(EC 3502)**				

Text Books		
1.	Title	Time harmonic Electromagnetics
	Author	R.F Harrington
	Publisher	McGraw Hill
	Edition	1961
2.	Title	Electromagnetic waves and Radiating Systems
	Author	Merrill I. Skolink
	Publisher	Prentice hall India
	Edition	2nd
Reference Books		
1.	Title	Antenna Theory

	Author	C.A. Balanis	
	Publisher	Wiley	
	Edition	Reprint, 2003.	
Course Contents	**UNIT I: Fundamentals of Electromagnetic Wave Propagation** Review of Maxwell's equations, Electromagnetic wave equations, Plane wave propagation, Propagation in free space, Wave polarization, Reflection and refraction of EM waves, Transmission line fundamentals, Propagation in lossy and lossless media, Skin effect and penetration depth.		**9**
	UNIT II: Advanced Wave Propagation Mechanisms Ground wave propagation, Sky wave propagation, Space wave propagation, Tropospheric propagation, Ionospheric propagation, Duct propagation, Fading and multipath propagation, Path loss models, Propagation at microwave and millimeter-wave frequencies.		**9**
	UNIT III: Advanced Antenna Theory and Design Antenna parameters and characteristics, Array antennas and array factor, Smart antennas, Microstrip patch antennas, Dielectric Resonator Antenna (DRA), Frequency Selective Surfaces (FSS), MIMO antennas, circularly polarized antennas, Mutual coupling reduction techniques.		**9**
	UNIT IV: Modern Antenna Applications and Computational Techniques Antenna measurement techniques, Radar and satellite antennas, Antennas for 4G/5G and IoT systems, Beamforming techniques, Computational electromagnetic methods, HFSS and CST simulations, Machine learning in antenna design, Metamaterial and reconfigurable antennas, Recent trends in antenna engineering.		**9**
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: EC 5258	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory		
Course Title	**Microwave Filter Design (EC 5259)**		
Course Objectives	• This course introduces the analysis and design of RF and microwave filters used in modern communication systems. It covers microwave network theory, filter approximations, distributed element filters, coupled-line structures, impedance matching, and CAD-based microwave filter design techniques.		

	• The course also includes practical aspects of microwave filter implementation using transmission line technologies and simulation tools.

Course Outcomes		**Cognitive Levels**
CO1	Understand microwave filter fundamentals and network analysis techniques.	Knowledge/Comprehension (Level I/Level-II)
CO2	Analyze and design RF and microwave filters using distributed components.	Analysis (Level-IV)
CO3	Apply CAD tools for simulation and implementation of microwave filters.	Application (Level-III)
CO4	Design coupled-line and impedance matching structures for microwave applications.	Synthesis/Evaluation (Level-VI/Level-V)

Semester	**II**	**Winter**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Electromagnetic Theory (EC3502), Antenna and Wave Propagation (EC3603)				

Text Books		
1.	Title	Microwave Engineering
	Author	David M. Pozar,
	Publisher	Wiley.
	Edition	3rd Edition
2.	Title	Microstrip Filters for RF/Microwave Applications
	Author	Jia-Sheng Hong and M. J. Lancaster
	Publisher	Wiley
	Edition	2nd ed.
Reference Books		
1.	Title	Microwave Filters, Impedance-Matching Networks and Coupling Structures
	Author	Matthaei, Young and Jones
	Publisher	Artech House
	Edition	2nd edition

Course Contents	**Unit-1: Fundamentals of Microwave Filters** Introduction to RF and microwave filters, filter characteristics and specifications, low-pass, high-pass, band-pass, and band-stop filters. Microwave network analysis, scattering parameters, insertion loss and return loss, filter approximations: Butterworth, Chebyshev, and Elliptic filters.	**9**

	Unit-2: Microwave Transmission Lines and Matching Transmission lines for microwave circuits, waveguides, stripline, microstrip, and slotline structures. Smith chart and impedance matching techniques. Lumped and distributed element approaches for microwave filter design.	**9**
	Unit-3: Microwave Filter Design Techniques Design of microwave filters using insertion loss method, coupled-line filters, stepped impedance filters, impedance transformers, power dividers, directional couplers, and hybrid circuits. Analysis of resonators and quality factor**.**	**9**
	Unit-4: Advanced Microwave Filters and CAD Tools Active and tunable microwave filters, RF MEMS and dielectric filters, microwave filter implementation issues, CAD tools for microwave filter simulation and optimization using HFSS, CST, and AWR Microwave Office.	**9**
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%

Course Code: EC 5259	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory		
Course Title	**Research Methodology for Engineers (EC 5260)**		
Course Objectives	• To introduce the philosophy of science, research ethics, and responsible conduct in research. • To understand research integrity, scientific misconduct, and publication ethics in academic research. • To familiarize students with indexing databases, citation metrics, open-access publishing, and research evaluation parameters. • To provide practical knowledge of plagiarism detection tools and ethical research practices.		

Course Outcomes		**Cognitive Levels**
CO1	Understand the philosophy of science, ethics, research integrity, and responsible conduct in engineering research.	Knowledge/Comprehension (Level-I/Level-II)
CO2	Analyze scientific misconduct, predatory publishing practices, and publication ethics in research environments.	Analysis (Level-IV)
CO3	Evaluate indexing databases, open-access publishing platforms, and research metrics used for academic assessment.	Evaluation (Level-V)
CO4	Apply plagiarism detection tools and ethical publication practices in research and technical writing.	Application/Synthesis (Level-III/Level-VI)

Semester	**II**	**Winter**

Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Nil				

Text Books		
1.	Title	Philosophy of Science
	Author	A. Bird
	Publisher	Routledge
	Edition	2006
2.	Title	A Short History of Ethics
	Author	Alasdair MacIntyre
	Publisher	London
	Edition	1967
3.	Title	Ethics in Competitive Research: Do not get scooped, do not get plagiarized
	Author	P. Chaddah
	Publisher	2018
	Edition	ISBN-978-9387480865
4.	Title	On Being a Scientist: A Guide to Responsible Conduct in Research
	Author	National Academy of Sciences, National Academy of Engineering and Institute of Medicine
	Publisher	National Academic Press
	Edition	3rd Edition, 2009
Reference Books		
1.	Title	What is Ethics in Research and Why it is Important?
	Author	D. B. Resnik
	Publisher	NIEHS
	Edition	2011
2.	Title	Predatory Publishers are Corrupting Open Access
	Author	J. Beall
	Publisher	Nature
	Edition	2012
3.	Title	Ethics in Science Education, Research and Governance
	Author	Indian National Science Academy

	Publisher	INSA	
	Edition	2019	
Course Contents	**UNIT I: Philosophy of Science and Research Ethics** Introduction to philosophy: definition, nature, scope, and branches of philosophy; introduction to ethics and moral philosophy; nature of moral judgement and ethical reasoning; ethics with respect to science and research; intellectual honesty and research integrity; responsible conduct in engineering and scientific research.		**9**
	UNIT II: Scientific Conduct and Publication Ethics Scientific misconduct: falsification, fabrication, and plagiarism (FFP); redundant publication, duplicate publication, overlapping publication, and salami slicing; selective reporting and misrepresentation of data; publication ethics: definition, importance, and standard practices; guidelines by COPE, WAME, and other organizations; conflicts of interest; publication misconduct and unethical practices; authorship and contributorship issues; predatory publishers and journals; identification of unethical publication practices.		**9**
	UNIT III: Open Access Publishing, Databases and Research Metrics Open access publications and initiatives; SHERPA/RoMEO publisher copyright and self-archiving policies; journal finder and journal suggestion tools such as JANE, Elsevier Journal Finder, and Springer Journal Suggestor; indexing databases and citation databases including Web of Science and Scopus; research metrics and evaluation parameters: Impact Factor, CiteScore, SNIP, SJR, IPP, h-index, g-index, i10-index, and altmetrics.		**9**
	UNIT IV: Publication Misconduct, Plagiarism Tools and Ethical Research Practices Subject-specific ethical issues in engineering research; group discussions on conflicts of interest, authorship disputes, complaints, and appeals; examples of scientific fraud and misconduct from India and abroad; plagiarism detection tools including Turnitin, Urkund, and open-source plagiarism software; ethical manuscript preparation and publication practices; best practices in academic and technical writing.		**9**
Course Assessment	Total Marks=100	Continuous Evaluation 20% Mid Semester 30% End Semester 50%	