VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF ELECTRONICS ENGINEERING

M. Tech Communication Engineering

(M.Tech MCE)

Curriculum

(*2021-2022 admitted students*)

VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

World class Education: Excellence in education, grounded in ethics and critical thinking, for improvement of life.

Cutting edge Research: An innovation ecosystem to extend knowledge and solve critical problems.

Impactful People: Happy, accountable, caring and effective workforce and students.

Rewarding Co-creations: Active collaboration with national & international industries & universities for productivity and economic development.

Service to Society: Service to the region and world through knowledge and compassion.

VISION STATEMENT OF THE SCHOOL OF ELECTRONICS ENGINEERING

To be a leader by imparting in-depth knowledge in Electronics Engineering, nurturing engineers, technologists and researchers of highest competence, who would engage in sustainable development to cater the global needs of industry and society.

MISSION STATEMENT OF THE SCHOOL OF ELECTRONICS ENGINEERING

- Create and maintain an environment to excel in teaching, learning and applied research in the fields of electronics, communication engineering and allied disciplines which pioneer for sustainable growth.
- Equip our students with necessary knowledge and skills which enable them to be lifelong learners to solve practical problems and to improve the quality of human life.

M. Tech. Communication Engineering

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be engineering practitioners and leaders, who would help solve industry's technological problems

2. Graduates will be engineering professionals, innovators or entrepreneurs engaged in technology development, technology deployment, or engineering system implementation in industry

3. Graduates will function in their profession with social awareness and responsibility

4. Graduates will interact with their peers in other disciplines in industry and society and contribute to the economic growth of the country

5. Graduates will be successful in pursuing higher studies in engineering or management

6. Graduates will pursue career paths in teaching or research

M. Tech Communication Engineering

PROGRAMME OUTCOMES (POs)

PO_01: Having an ability to apply mathematics and science in engineering applications.

PO_03: Having an ability to design a component or a product applying all the relevant standards and with realistic constraints, including public health, safety, culture, society and environment

PO_04: Having an ability to design and conduct experiments, as well as to analyse and interpret data, and synthesis of information

PO_05: Having an ability to use techniques, skills, resources and modern engineering and IT tools necessary for engineering practice

PO_06: Having problem solving ability- to assess social issues (societal, health, safety, legal and cultural) and engineering problems

PO_07: Having adaptive thinking and adaptability in relation to environmental context and sustainable development

PO_08: Having a clear understanding of professional and ethical responsibility

PO_11: Having a good cognitive load management skills related to project management and finance

M. Tech Communication Engineering

ADDITIONAL PROGRAMME OUTCOMES (APOs)

APO_02: Having Sense-Making Skills of creating unique insights in what is being seen or observed (Higher level thinking skills which cannot be codified)

APO_03: Having design thinking capability

APO_04: Having computational thinking (Ability to translate vast data in to abstract concepts and to understand database reasoning

APO_07: Having critical thinking and innovative skills

APO_08: Having a good digital footprint

M. Tech Communication Engineering

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M. Tech. (Communication Engineering) programme, graduates will be able to

PSO1: Apply advanced concepts of Communication Engineering to design and develop more efficient next generation communication systems.

PSO2: Use modern technologies in both hardware, software to solve real-world multidisciplinary problems

PSO3: Independently carry out research on diverse communication strategies to address practical problems and present a substantial technical report.

M. Tech Communication Engineering

CREDIT STRUCTURE

Category-wise Credit distribution

Category	Credits
University core (UC)	**27**
Programme core (PC)	**19**
Programme elective (PE)	**18**
University elective (UE)	**06**
Bridge course (BC)	**-**
Total credits	**70**

M. Tech Communication Engineering

DETAILED CURRICULUM

University Core

S. No	Course Code	Course title	L	T	P	J	C
1	MAT 5006	Mathematics for Communication Engineering	3	0	0	0	3
2	ENG5001 ENG5002 GER 5001	Fundamentals of Communication Skills Professional and Communication Skills (OR) Deutsch fuer Anfaenger	0 0 2	0 0 0	2 2 0	0 0 0	1 1 2
3	STS5001 STS5002	Soft Skills Soft Skills	-	-	-	-	2
4	SET5001 SET5002	SET Projects SET Projects	-	-	-	-	4
5	ECE 6099	Master's Thesis	-	-	-	-	16
	Total Credits						27

M. Tech Communication Engineering

Programme Core

S. No.	Course Code	Course title	L	T	P	J	C
1.	ECE 5005	Advances in Wireless Networks	2	0	2	4	4
2.	ECE 5010	Advanced Digital Communication	2	0	2	4	4
3.	ECE 5011	Advanced Digital Signal Processing	2	0	2	4	4

4.	ECE 5012	Advanced Antenna Engineering	3	0	2	0	4
5.	ECE 5013	Fiber Optic Communication and Networks	2	0	2	0	3
		Total Credits					19

M. Tech Communication Engineering

Programme Elective

S. No.	Course Code	Course title	L	T	P	J	C
1.	ECE 6010	High Performance Communication Networks	3	0	0	0	3
2.	ECE 6011	Mobile Adhoc Networks	3	0	0	0	3
3.	ECE 6012	Modern Wireless Communication Systems	3	0	0	4	4
4.	ECE 6013	Modeling of Wireless Communication Systems	3	0	2	0	4
5.	ECE 6014	Modern Satellite Communication	3	0	0	0	3
6.	ECE 6015	Coding for MIMO Communication	3	0	0	0	3
7.	ECE 6016	Advanced Wireless Sensor Networks	2	0	2	0	3
8.	ECE 6017	RF and Microwave Circuit Design	2	0	2	4	4
9.	ECE 6018	Microwave Integrated Circuits	3	0	0	0	3
10.	ECE 6019	Image processing and Feature Extraction	3	0	2	0	4
11.	ECE 6020	Multirate Systems	2	0	0	4	3
12.	ECE 6021	Adaptive Signal Processing	2	0	0	4	3
13.	ECE 6022	Optical Broadband Access Networks	2	0	0	4	3
14.	ECE 6023	RF MEMS	3	0	0	0	3
15.	ECE 6091	Foundations of Machine Learning	3	0	0	0	3
16.	CSE 6051	Information and Network Security	3	0	0	0	3

Course Code	Course Title	L	T	P	J	C
MAT5006	Mathematics for Communication Engineering	3	0	0	0	3
Pre-requisite	None	Syllabus version				
		1.0				

Course Objectives:

1. To build the strong foundation in Mathematics in students needed for the field of Communication Engineering.
2. To provide the mathematics fundamentals necessary to formulate, solve and analyse complex engineering problems.
3. To apply reasoning by the contextual knowledge to engineering practice.
4. To work as teams on multi-disciplinary projects.

Expected Course Outcomes:

At the end of this course, the students are expected to

1. Apply matrix theory in Communication Engineering problems.
2. Calculate gradients, derivatives and its applications
3. Apply the constrained optimization for approximate solutions.
4. Do statistical modelling and analysis of Communication Systems
5. Apply Markovian process and distinguish the utility of queuing models.

Module:1	Basic Matrix Concepts	6 hours

Linear equations and matrix representations, Determinants. Vector spaces- Basis and dimension, Norms and inner-products, The Cauchy- Schwarz inequality, Direction of vectors, weighted inner products, Expectation as an inner product, Hilbert and Banach spaces, orthogonal subspaces, null space, column space, row space. Projection matrices.

Module:2	Matrix Factorizations and applications	9 hours

The LU factorization-Methods of Crout and Cholesky factorization, unitary matrices and the QR factorization, Eigen values, Eigen vectors, EVD, whitening, Pseudo inverses and the SVD, numerically sensitive problems, Rank-reducing approximations.

Module:3	Some Special Matrices and their Applications	4 hours

Circulant matrices, Toeplitz matrices. Kronecker Products - Some applications of Kronecker products.

Module:4	Derivatives and gradients	4 hours

Derivatives of vectors and scalars, products of matrices, powers of a matrix, Modifications for derivatives of complex vectors and matrices, first order systems

Module:5	Theory of Constrained optimization	5 hours

Basic definitions, definitions of constrained optimization, equality constraints: Lagrange multipliers.

Module:6	Probability and random processes	7 hours

Random vectors, transformations, joint moments, joint characteristic function, correlation, covariance matrices - properties. Vector Gaussian, Q-function, Circular complex Gaussian, various transformations, Gaussian random vectors, Rayleigh, Rician, Nagakami distributions, probability of error upper

bounds for M-ary modulations.		
Module:7	**Markov Chains Queuing theory**	**8 hours**
Markov Process, Markov chains, Birth-Death process- Characteristics of queuing models –Kendall's notation - Transient and Steady States and Difference equations related to Poisson Queue systems – Single server and Multiple Server Poisson queue Models with Finite and Infinite capacity.		
Module:8	**Contemporary issues:** Expert Lecture	**2 hours**
Applications of Constrained optimization and Queuing Theory		
	Total Lecture hours:	**45 hours**

Text Book(s)

1	Todd.K. Moon and Wynne Stirling, Mathematical methods and algorithms for signal processing, 2000, Prentice Hall, 2000. New York.
2	John G. Proakis, Masoud Salehi, Digital Communications, 2008, 5th edition, McGrawHill.
3	T.Veerarajan, Probability, Statistics and Random Processes, 2009, 3rd edition, McGrawHill.

Reference Books

1. Gilbert Strang, Introduction to Linear Algebra, 2009, 4th edition, Wellesley-Cambridge press.
2. E. Larsson, P. Stoica, Space time block coding for wireless communications, 2003, Cambridge University press.
3. P.P. Vaidyanadhan, Multirate systems and filter banks, 1993, Pearson India.
   Dimitris G. Manolakis, Vinay K. Ingle, Stephen M. Kogon, Statistical and adaptive signal processing: Spectral estimation, signal modelling, adaptive filtering and array processing, 2005, Artech House.
4. Athanasios Papoulis, S Pillai , Probability, Random Variables and Stochastic Processes, 2014 (reprint), 4th Edition, McGraw-Hill.
5. Kishor S. Trivedi, Probability and Statistics with Reliability, Queuing, and Computer Science Applications, 2016, 2nd Edition, John-Wiley & Sons.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	09-03-2016		
Approved by Academic Council	No. 40	Date	18-03-2016

Course Code	Course Title	L	T	P	J	C
ENG5001	Fundamentals of Communication Skills	0	0	2	0	1
Pre-requisite	Not cleared EPT (English Proficiency Test)	Syllabus version				
		1.0				

Course Objectives:

1. To enable learners learn basic communication skills - Listening, Speaking, Reading and Writing
2. To help learners apply effective communication in social and academic context
3. To make students comprehend complex English language through listening and reading

Expected Course Outcome:

1. Enhance the listening and comprehending skills of the learners
2.Acquire speaking skills to express their thoughts freely and fluently
3.Learn strategies for effective reading
4.Write grammatical correct sentences in general and academic writing
5. Develop technical writing skills like writing instructions, transcoding etc.,

Module:1	Listening	**8 hours**
Understanding Conversation Listening to Speeches Listening for Specific Information		
Module:2	Speaking	**4 hours**
Exchanging Information Describing Activities, Events and Quantity		
Module:3	Reading	**6 hours**
Identifying Information Inferring Meaning Interpreting text		
Module:4	Writing: Sentence	**8 hours**
Basic Sentence Structure Connectives Transformation of Sentences Synthesis of Sentences		
Module:5	Writing: Discourse	**4 hours**
Instructions Paragraph Transcoding		
	Total Lecture hours:	**30 hours**

Text Book(s)

1. Redston, Chris, Theresa Clementson, and Gillie Cunningham. Face2face Upper Intermediate Student's Book, 2013, Cambridge University Press.

Reference Books

1. Chris Juzwiak .Stepping Stones: A guided approach to writing sentences and Paragraphs (Second Edition), 2012, Library of Congress.
2. Clifford A Whitcomb & Leslie E Whitcomb, Effective Interpersonal and Team Communication Skills for Engineers, 2013, John Wiley & Sons, Inc., Hoboken: New Jersey.
3. ArunPatil, Henk Eijkman &Ena Bhattacharya, New Media Communication Skills for

	Engineers and IT Professionals,2012, IGI Global, Hershey PA.
4.	Judi Brownell, Listening: Attitudes, Principles and Skills, 2016, 5th Edition, Routledge:USA
5.	John Langan, Ten Steps to Improving College Reading Skills, 2014, 6th Edition, Townsend Press:USA
6.	Redston, Chris, Theresa Clementson, and Gillie Cunningham. Face2face Upper Intermediate Teacher's Book. 2013, Cambridge University Press.
	Authors, book title, year of publication, edition number, press, place

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)

1.	Familiarizing students to adjectives through brainstorming adjectives with all letters of the English alphabet and asking them to add an adjective that starts with the first letter of their name as a prefix.	2 hours
2.	Making students identify their peer who lack Pace, Clarity and Volume during presentation and respond using Symbols.	4 hours
3.	Using Picture as a tool to enhance learners speaking and writing skills	2 hours
4.	Using Music and Songs as tools to enhance pronunciation in the target language / Activities through VIT Community Radio	2 hours
5.	Making students upload their Self- introduction videos in Vimeo.com	4 hours
6.	Brainstorming idiomatic expressions and making them use those in to their writings and day to day conversation	4 hours
7.	Making students Narrate events by adding more descriptive adjectives and add flavor to their language / Activities through VIT Community Radio	4 hours
8	Identifying the root cause of stage fear in learners and providing remedies to make their presentation better	4 hours
9	Identifying common Spelling & Sentence errors in Letter Writing and other day to day conversations	2 hours
10.	Discussing FAQ's in interviews with answers so that the learner gets a better insight in to interviews / Activities through VIT Community Radio	2 hours
	Total Practical Hours	**30 hours**

Mode of evaluation: Online Quizzes, Presentation, Role play, Group Discussions, Assignments, Mini Project

Recommended by Board of Studies	22-07-2017		
Approved by Academic Council	No. 46	Date	24-8-2017

Course Code	Course Title	L	T	P	J	C
ENG5002	Professional and Communication Skills	0	0	2	0	1
Pre-requisite	ENG5001	Syllabus version				
		1.1				

Course Objectives:

1. To enable students to develop effective Language and Communication Skills
2. To enhance students' Personal and Professional skills
3. To equip the students to create an active digital footprint

Expected Course Outcome:

1. Improve inter-personal communication skills
2. Develop problem solving and negotiation skills
3. Learn the styles and mechanics of writing research reports
4. Cultivate better public speaking and presentation skills
5. Apply the acquired skills and excel in a professional environment

Module:1	**Personal Interaction**	**2 hours**

Introducing Oneself- one's career goals
Activity: SWOT Analysis

Module:2	**Interpersonal Interaction**	**2 hours**

Interpersonal Communication with the team leader and colleagues at the workplace
Activity: Role Plays/Mime/Skit

Module:3	**Social Interaction**	**2 hours**

Use of Social Media, Social Networking, gender challenges
Activity: Creating LinkedIn profile, blogs

Module:4	**Résumé Writing**	**4 hours**

Identifying job requirement and key skills
Activity: Prepare an Electronic Résumé

Module:5	**Interview Skills**	**4 hours**

Placement/Job Interview, Group Discussions
Activity: Mock Interview and mock group discussion

Module:6	**Report Writing**	**4 hours**

Language and Mechanics of Writing
Activity: Writing a Report

Module:7	**Study Skills: Note making**	**2hours**

Summarizing the report
Activity: Abstract, Executive Summary, Synopsis

Module:8	**Interpreting skills**	**2 hours**

Interpret data in tables and graphs
Activity: Transcoding

Module:9	**Presentation Skills**	**4 hours**

Oral Presentation using Digital Tools Activity: Oral presentation on the given topic using appropriate non-verbal cues		
Module:10	**Problem Solving Skills**	**4 hours**
Problem Solving & Conflict Resolution Activity: Case Analysis of a Challenging Scenario		
	Total Lecture hours:	**30 hours**

Text Book(s)

1. Bhatnagar Nitin and Mamta Bhatnagar, Communicative English For Engineers And Professionals, 2010, Dorling Kindersley (India) Pvt. Ltd.

Reference Books

1. Jon Kirkman and Christopher Turk, Effective Writing: Improving Scientific, Technical and Business Communication, 2015, Routledge
2. Diana Bairaktarova and Michele Eodice, Creative Ways of Knowing in Engineering, 2017, Springer International Publishing
3. Clifford A Whitcomb & Leslie E Whitcomb, Effective Interpersonal and Team Communication Skills for Engineers, 2013, John Wiley & Sons, Inc., Hoboken: New Jersey.
4. ArunPatil, Henk Eijkman & Ena Bhattacharya, New Media Communication Skills for Engineers and IT Professionals, 2012, IGI Global, Hershey PA.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)

1.	SWOT Analysis – Focus specially on describing two strengths and two weaknesses	2 hours
2.	Role Plays/Mime/Skit -- Workplace Situations	4 hours
3.	Use of Social Media – Create a LinkedIn Profile and also write a page or two on areas of interest	2 hours
4.	Prepare an Electronic Résumé and upload the same in vimeo	2 hours
5.	Group discussion on latest topics	4 hours
6	Report Writing – Real-time reports	2 hours
7	Writing an Abstract, Executive Summary on short scientific or research articles	4 hours
8	Transcoding – Interpret the given graph, chart or diagram	2 hours
9	Oral presentation on the given topic using appropriate non-verbal cues	4 hours
10	Problem Solving -- Case Analysis of a Challenging Scenario	4 hours
	Total Laboratory Hours	**30 hours**

Mode of evaluation: : Online Quizzes, Presentation, Role play, Group Discussions, Assignments, Mini Project

Recommended by Board of Studies	22-07-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
GER5001	Deutsch für Anfänger	2	0	0	0	2
Pre-requisite	NIL	Syllabus version				
		v.1				

Course Objectives:

The course gives students the necessary background to:

1. Enable to read and communicate in German in their day to day life
2. Become industry-ready
3. Make them understand the usage of grammar in the German Language.

Expected Course Outcome:

The students will be able to

1. Create the basics of German language in their day to day life.
2. Understand the conjugation of different forms of regular/irregular verbs.
3. Understand the rule to identify the gender of the Nouns and apply articles appropriately.
4. Apply the German language skill in writing corresponding letters, E-Mails etc.
5. Create the talent of translating passages from English-German and vice versa and To frame simple dialogues based on given situations.

Module:1	3 hours

Einleitung, Begrüssungsformen, Landeskunde, Alphabet, Personalpronomen, Verb Konjugation, Zahlen (1-100), W-fragen, Aussagesätze, Nomen – Singular und Plural

Lernziel:

Elementares Verständnis von Deutsch, Genus- Artikelwörter

Module:2	3 hours

Konjugation der Verben (regelmässig /unregelmässig) die Monate, die Wochentage, Hobbys, Berufe, Jahreszeiten, Artikel, Zahlen (Hundert bis eine Million), Ja-/Nein- Frage, Imperativ mit Sie

Lernziel :

Sätze schreiben, über Hobbys erzählen, über Berufe sprechen usw.

Module:3	4 hours

Possessivpronomen, Negation, Kasus- AkkusatitvundDativ (bestimmter, unbestimmterArtikel), trennnbare verben, Modalverben, Adjektive, Uhrzeit, Präpositionen, Mahlzeiten, Lebensmittel, Getränke

Lernziel :

Sätze mit Modalverben, Verwendung von Artikel, über Länder und Sprachen sprechen, über eine Wohnung beschreiben.

Module:4	6 hours

Übersetzungen : (Deutsch – Englisch / Englisch – Deutsch)

Lernziel :

Grammatik – Wortschatz – Übung

Module:5	5 hours

Leseverständnis,Mindmap machen,Korrespondenz- Briefe, Postkarten, E-Mail

Lernziel :

Wortschatzbildung und aktiver Sprach gebrauch

Module:6	.	**3 hours**
Aufsätze : Meine Universität, Das Essen, mein Freund oder meine Freundin, meine Familie, ein Fest in Deutschland usw		
Module:7		**4 hours**
Dialoge: a) Gespräche mit Familienmitgliedern, Am Bahnhof, b) Gespräche beim Einkaufen ; in einem Supermarkt ; in einer Buchhandlung ; c) in einem Hotel - an der Rezeption ;ein Termin beim Arzt. Treffen im Cafe		
Module:8		**2 hours**
Guest Lectures/Native Speakers / Feinheiten der deutschen Sprache, Basisinformation über die deutschsprachigen Länder		
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	**Studio d A1 Deutsch als Fremdsprache, Hermann Funk, Christina Kuhn, Silke Demme : 2012**
Reference Books	
1	Netzwerk Deutsch als Fremdsprache A1, Stefanie Dengler, Paul Rusch, Helen Schmtiz, Tanja Sieber, 2013
2	Lagune ,Hartmut Aufderstrasse, Jutta Müller, Thomas Storz, 2012.
3	Deutsche SprachlehrefürAUsländer, Heinz Griesbach, Dora Schulz, 2011
4	ThemenAktuell 1, HartmurtAufderstrasse, Heiko Bock, MechthildGerdes, Jutta Müller und Helmut Müller, 2010
	www.goethe.de wirtschaftsdeutsch.de hueber.de klett-sprachen.de www.deutschtraning.org

Mode of Evaluation: CAT / Assignment / Quiz / Seminar / FAT			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	41	Date	17-06-2016

Course Code	Course Title	L	T	P	J	C
STS 5001	Essentials of Business Etiquette and problem solving	3	0	0	0	1
Pre-requisite	None	Syllabus version				

Course Objectives:

1. To develop the students' logical thinking skills
2. To learn the strategies of solving quantitative ability problems
3. To enrich the verbal ability of the students
4. To enhance critical thinking and innovative skills

Expected Course Outcome:

1. Enabling students to use relevant aptitude and appropriate language to express themselves
2. To communicate the message to the target audience clearly
3. The students will be able to be proficient in solving quantitative aptitude and verbal ability questions of various examinations effortlessly

Module:1	Business Etiquette: Social and Cultural Etiquette and Writing Company Blogs and Internal Communications and Planning and Writing press release and meeting notes	9 hours

Value, Manners, Customs, Language, Tradition, Building a blog, Developing brand message, FAQs', Assessing Competition, Open and objective Communication, Two way dialogue, Understanding the audience, Identifying, Gathering Information, Analysis, Determining, selecting plan, Progress check, Types of planning, Write a short, catchy headline, Get to the Point – summarize your subject in the first paragraph., Body – Make it relevant to your audience,

Module:2	Study skills – Time management skills	3 hours

Prioritization, Procrastination, Scheduling, Multitasking, Monitoring, working under pressure and adhering to deadlines

Module:3	Presentation skills – Preparing presentation and Organizing materials and Maintaining and preparing visual aids and Dealing with questions	7 hours

10 Tips to prepare PowerPoint presentation, Outlining the content, Passing the Elevator Test, Blue sky thinking, Introduction , body and conclusion, Use of Font, Use of Color, Strategic presentation, Importance and types of visual aids, Animation to captivate your audience, Design of posters, Setting out the ground rules, Dealing with interruptions, Staying in control of the questions, Handling difficult questions

Module:4	Quantitative Ability -L1 – Number properties and Averages and Progressions and Percentages and Ratios	11 hours

Number of factors, Factorials, Remainder Theorem, Unit digit position, Tens digit position, Averages, Weighted Average, Arithmetic Progression, Geometric Progression, Harmonic Progression, Increase & Decrease or successive increase, Types of ratios and proportions

Module:5	Reasoning Ability-L1 – Analytical Reasoning	8 hours

Data Arrangement (Linear and circular & Cross Variable Relationship), Blood Relations, Ordering/ranking/grouping, Puzzle test, Selection Decision table

Module:6	**Verbal Ability-L1 – Vocabulary Building**	**7 hours**
Synonyms & Antonyms, One-word substitutes, Word Pairs, Spellings, Idioms, Sentence completion, Analogies		
	Total Lecture hours:	**45 hours**

Reference Books	
1.	Kerry Patterson, Joseph Grenny, Ron McMillan, Al Switzler, Crucial Conversations: Tools for Talking When Stakes are High, 2001, McGraw-Hill Contemporary, Bangalore.
2.	Dale Carnegie, How to Win Friends and Influence People, 1936, New York. Gallery Books
3.	Scott Peck. M, Road Less Travelled. 1978, New York City.
4.	FACE, Aptipedia Aptitude Encyclopedia, 2016. Delhi. Wiley publications
5.	ETHNUS, Aptimithra, 2013, McGraw-Hill Education Pvt. Ltd, Bangalore.
Websites:	
1.	**www.chalkstreet.com**
2.	**www.skillsyouneed.com**
3.	**www.mindtools.com**
4.	**www.thebalance.com**
5.	**www.eguru.ooo**

Mode of Evaluation: FAT, Assignments, Projects, Case studies, Role plays, 3 Assessments with Term End FAT (Computer Based Test)

Course Code	Course Title	L	T	P	J	C
STS5002	Preparing for Industry	3	0	0	0	1
Pre-requisite	None	Syllabus version				
		1				

Course Objectives:

1. To challenge students to explore their problem-solving skills
2. To develop essential skills to tackle advance quantitative and verbal ability questions
3. To have working knowledge of communicating in English

Expected Course Outcome:

1. Enabling students to simplify, evaluate, analyze and use functions and expressions to simulate real situations to be industry ready.
2. The students will be able to interact confidently and use decision making models effectively
3. The students will be able to be proficient in solving quantitative aptitude and verbal ability questions of various examinations effortlessly

Module:1	Interview skills – Types of interview and Techniques to face remote interviews and Mock Interview	3 hours

Structured and unstructured interview orientation, Closed questions and hypothetical questions, Interviewers' perspective, Questions to ask/not ask during an interview, Video interview¸ Recorded feedback, Phone interview preparation, Tips to customize preparation for personal interview, Practice rounds

Module:2	Resume skills – Resume Template and Use of power verbs and Types of resume and Customizing resume	2 hours

Structure of a standard resume, Content, color, font, Introduction to Power verbs and Write up, Quiz on types of resume, Frequent mistakes in customizing resume, Layout - Understanding different company's requirement, Digitizing career portfolio

Module:3	Emotional Intelligence - L1 – Transactional Analysis and Brain storming and Psychometric Analysis and Rebus Puzzles/Problem Solving	12 hours

Introduction, Contracting, ego states, Life positions, Individual Brainstorming, Group Brainstorming, Stepladder Technique, Brain writing, Crawford's Slip writing approach, Reverse brainstorming, Star bursting, Charlette procedure, Round robin brainstorming, Skill Test, Personality Test, More than one answer, Unique ways

Module:4	Quantitative Ability-L3 – Permutation-Combinations and Probability and Geometry and mensuration and Trigonometry and Logarithms and Functions and Quadratic Equations and Set Theory	14 hours

Counting, Grouping, Linear Arrangement, Circular Arrangements, Conditional Probability, Independent and Dependent Events, Properties of Polygon, 2D & 3D Figures, Area & Volumes, Heights and distances, Simple trigonometric functions, Introduction to logarithms, Basic rules of logarithms, Introduction to functions, Basic rules of functions, Understanding Quadratic Equations, Rules & probabilities of Quadratic Equations, Basic concepts of Venn Diagram

Module:5	**Reasoning ability-L3 – Logical reasoning and Data Analysis and Interpretation**	**7 hours**
Syllogisms, Binary logic, Sequential output tracing, Crypto arithmetic, Data Sufficiency, Data interpretation-Advanced, Interpretation tables, pie charts & bar chats		
Module:6	**Verbal Ability-L3 – Comprehension and Logic**	**7 hours**
Reading comprehension, Para Jumbles, Critical Reasoning (a) Premise and Conclusion, (b) Assumption & Inference, (c) Strengthening & Weakening an Argument		
	Total Lecture hours:	**45 hours**

References

1. Michael Farra and JIST Editors, Quick Resume & Cover Letter Book: Write and Use an Effective Resume in Just One Day, 2011. Saint Paul, Minnesota. Jist Works
2. Daniel Flage Ph.D, The Art of Questioning: An Introduction to Critical Thinking, (2003), London. Pearson
3. FACE, Aptipedia Aptitude Encyclopedia, 2016, Wiley publications, Delhi.

Mode of Evaluation: FAT, Assignments, Projects, Case studies, Role plays, 3 Assessments with Term End FAT (Computer Based Test)

Course Code	Course Title	L	T	P	J	C
SET5001	SCIENCE, ENGINEERING AND TECHNOLOGY PROJECT– I					2

Pre-requisite	Syllabus Version
	1.10

Course Objectives:

- To provide opportunity to involve in research related to science / engineering
- To inculcate research culture
- To enhance the rational and innovative thinking capabilities

Expected Course Outcome:

On completion of this course, the student should be able to:

1. Identify problems that have relevance to societal / industrial needs
2. Exhibit independent thinking and analysis skills
3. Demonstrate the application of relevant science / engineering principles

Modalities / Requirements

1. Individual or group projects can be taken up
2. Involve in literature survey in the chosen field
3. Use Science/Engineering principles to solve identified issues
4. Adopt relevant and well-defined / innovative methodologies to fulfill the specified objective
5. Submission of scientific report in a specified format (after plagiarism check)

Student Assessment : Periodical reviews, oral/poster presentation

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
SET5002	SCIENCE, ENGINEERING AND TECHNOLOGY PROJECT– II					2

Pre-requisite	Syllabus Version
	1.10

Course Objectives:

1. To provide opportunity to involve in research related to science / engineering
2. To inculcate research culture
3. To enhance the rational and innovative thinking capabilities

Expected Course Outcome:

On completion of this course, the student should be able to:

1. Identify problems that have relevance to societal / industrial needs
2. Exhibit independent thinking and analysis skills
3. Demonstrate the application of relevant science / engineering principles

Modalities / Requirements

1. Individual or group projects can be taken up
2. Involve in literature survey in the chosen field
3. Use Science/Engineering principles to solve identified issues
4. Adopt relevant and well-defined / innovative methodologies to fulfill the specified objective
5. Submission of scientific report in a specified format (after plagiarism check)

Student Assessment : Periodical reviews, oral/poster presentation

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
ECE6099	Masters Thesis	0	0	0	0	16
Pre-requisite	As per the academic regulations	Syllabus version				
		1.0				

Course Objectives:

To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field.

Expected Course Outcome:

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

1. Formulate specific problem statements for ill-defined real life problems with reasonable assumptions and constraints.
2. Perform literature search and / or patent search in the area of interest.
3. Conduct experiments / Design and Analysis / solution iterations and document the results.
4. Perform error analysis / benchmarking / costing
5. Synthesise the results and arrive at scientific conclusions / products / solution
6. Document the results in the form of technical report / presentation

Contents

Capstone Project may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
Project should be for two semesters based on the completion of required number of credits as per the academic regulations.

Should be individual project.

In case of group projects, the individual project report of each student should specify the individual's contribution to the group project.

Carried out inside or outside the university, in any relevant industry or research institution.

Publications in the peer reviewed journals / International Conferences will be an added advantage

Mode of Evaluation: Periodic reviews, Presentation, Final oral viva, Poster submission

Recommended by Board of Studies	10-06-2015		
Approved by Academic Council	No. 37	Date	16-06-2015

Programme Core

Course Code	Course Title	L	T	P	J	C
ECE5005	Advances in Wireless Networks	2	0	2	4	4
Pre-requisite	Nil	Syllabus version				
		1.0				

Course Objectives:

1. To teach the basics of wireless networks and its services from 1G to 5G.
2. To acquaint with 3GPP based wireless IP networks and its architecture.
3. To teach the operation of LTE network, IMS architecture, inter networking concepts, addressing and registration process in wireless networks.
4. To teach the significance of mobility management in next generation network and its QoS challenges.

Course Outcomes:

1. Understand the different types of wireless standards and its services.
2. Comprehend the principles of 3GPP Packet Data Network Architecture, Packet Data Protocol (PDP) and accessing IP network through PS domain.
3. Comprehend the architecture of LTE network, protocol architecture and inter working with other RATs.
4. Comprehend the architecture of IP Multimedia Subsystem (IMS) and addressing procedure of IMS.
5. Analyze the mobility management IP based 3GPP and LTE networks.
6. Examine the QoS in Wireless IP networks.
7. Evaluate the performance of routing protocol, handover procedure and throughput of different network (3G and 4G Network) using Qualnet and NetSim tools.
8. Design and analyze the system parameters and QoS of next generation network using 3GPP and IEEE standards.

Module:1	Evolution of Wireless Standards	4 hours

Evolution of wireless networks and services, Introduction to 1G/2G/3G/4G/5G, Motivation for IP based wireless networks, Long Term Evolution (LTE), Technologies for LTE, Evolutions from LTE to LTE-A - WiMAX Evolution (IEEE 802.16 family), Cognitive radio (IEEE 802.22).

Module:2	Wireless IP Network Architecture	6 hours

3GPP packet data networks, Network architecture, Packet Data Protocol (PDP), Context, Configuring PDP addresses on mobile stations, Accessing IP networks through PS domain.

Module:3	LTE Network Architecture	3 hours

LTE network architecture, Roaming architecture, Protocol architecture, Bearer establishment procedure, Inter, Working with other RATs

Module:4	IP Multimedia Subsystem	4 hours

IP Multimedia Subsystem (IMS), IMS architecture, Mobile station addressing for accessing the IMS, Registration and deregistration with the IMS, End-to-End signaling flows

Module:5	Mobility Management in IP and 3GPP	6 hours

Basic issues in mobility management, Location management, Mobility management in IP networks, MIPv4 regional registration, SIP-based mobility management, Cellular IP, HAWAII,

Mobility management in 3GPP packet networks, Packet Mobility Management (PMM), Context-paging initiated by Packet-Switched Core Network		
Module:6	**Mobility Management in LTE Networks**	**2 hours**
Intra-LTE mobility, Inter-RAT mobility, Mobility over X2 interface		
Module:7	**Quality of Service**	**3 hours**
QoS challenges in wireless IP Networks, QoS in 3GPP, QoS architecture, Management and classes, QoS attributes, Management of End-to-End IP QoS, EPS bearers and QoS in LTE networks.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Jyh-Cheng Chen, Tao Zhang, IP-Based Next-Generation Wireless Networks Systems, Architectures, and Protocols, 2012, 2nd Edition, John Wiley & Sons, New Jersey.
2.	StefaniaSesia, IssamToufik, Matthew Baker, LTE – The UMTS Long Term Evolution From Theory to Practice, 2011, 2nd Edition, John Wiley & Sons, New Jersey.
Reference Books	
1.	Ayman ElNashar, Mohamed El-saidny, Mahmoud Sherif, Design, Deployment and Performance of 4G-LTE Networks: A Practical Approach, 2014, 1st Edition, John Wiley & Sons, New Jersey.
2.	Jonathan Rodriguez, Fundamentals of 5G Mobile Networks, 2015, 1st Edition, Wiley Publications, United States.
3.	Savo Glisic, Advanced Wireless Networks: 5G Technology, 2016, 1st Edition, Wiley Publications, United States.
4.	http://www.cse.wustl.edu/~jain/cse574-14/index.html
Mode of Evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)	

List of Challenging Experiments (Indicative)		
1.	Implement any two scheduling methods in LTE networks for various traffics and scenarios. Also, propose an improved scheduling from any one of those scheduling methods.	3 hours
2.	Develop UMTS architecture to route packet data from the user equipment to the IP network and evaluate the network performance in terms of throughput, delay and jitter.	3 hours
3.	Design an UMTS network to perform handoff between UE in a UMTS network within a single SGSN and between two SGSNs	3 hours
4.	Evaluate the performance of the following routing protocols for low and high speed wireless networks: (a) Bordercast Resolution Protocol (BRP) (b) Location Aided Routing (LAR) Protocol (c) Zone Routing Protocol (ZRP)	3 hours
5.	Design a 3G network to route data between same PLMN but between two different SGSN nodes and two different PLMN UMTS network	3 hours
6.	Design an UMTS network to study the routing effects of OSPF ver. 2 on core network components (HLR, GGSN and SGSN)	3 hours
7.	Design a HSDPA network and evaluate its performance in terms of	3 hours

	throughput, delay and jitter.	
8.	Design a WiMAX network to evaluate the performance of mobility models, namely, file based mobility and random way point mobility.	3 hours
9.	To analyse the performance (Energy Consumption and Delay) of discontinuous reception in LTE networks (3GPP TS 36) for VoIP traffic.	3 hours
10.	To analyse the performance (throughput, delay, jitter and packet loss rate) of LTE network under Type I and Type II relay.	3 hours
	Total laboratory hours	**30 hours**

Mode of evaluation :Continuous Assessment & Final Assessment Test (FAT)			
Recommended by Board of Studies	13-12-2015		
Approved by Academic Council	No. 40	Date	18-03-2016

Course Code	Course Title	L	T	P	J	C
ECE5010	Advanced Digital Communication	2	0	2	4	4
Pre-requisite	Nil	Syllabus version				
		1.0				

Course Objectives:

1. To introduce the concept of digital base-band data transmission through a band limited channel.
2. To familiarize the student with concept of binary and M-ary band-pass modulation schemes.
3. To introduce the advanced channel coding techniques to minimize the probability of error.
4. To acquaint with the emerging trends in digital communication field.

Course Outcomes:

1. Design matched filter for detection of digital signals in the presence of white Gaussian noise.
2. Design waveforms to overcome ISI in band-limited channels.
3. Design equalization circuits to overcome the effect of channel distortion.
4. Compute probability of error for binary digital modulation schemes in the presence of AWGN.
5. Extend the binary modulation schemes to M-ary modulation for symbols.
6. Design turbo and LDPC codes to overcome the effect of noise in the channel.
7. Use MATLAB and Simulink to experiment and experience the above digital modulation concepts.
8. Understand the IEEE standards research papers, replicate and extend those results.

Module:1	Introduction to Detection and Estimation Theory	4 hours

Detection of known signals in noise, Correlation receiver, Matched filter receiver, Detection of signals with unknown phase in noise. Minimum mean square error estimator, Maximum a posteriori estimator, Maximum likelihood estimation, Cramer Rao bound (CRB) for parameter estimation.

Module:2	Baseband Transmission Techniques	3 hours

Digital transmission through band limited channels, Power spectrum of digitally modulated signals, Signal design for band limited channels, Band limited signal design for zero ISI, Band limited signal design for controlled ISI.

Module:3	Baseband Reception Techniques	3 hours

Probability of error in detection of digital PAM, Eye pattern, Channel equalization, Linear Equalizers, Adaptive equalizers, Decision feedback equalizers, Fractionally spaced equalizers.

Module:4	Binary Bandpass Modulation Schemes	5 hours

Binary modulation schemes, Coherent and non-coherent detection of binary modulation schemes, Performance analysis of binary modulation schemes under AWGN channel, Minimum Shift Keying (MSK), Gaussian Minimum Shift Keying (GMSK).

Module:5	M-ary Bandpass Modulation Schemes	5 hours

M-ary Phase Shift Keying, M-ary Quadrature Amplitude Modulation, M-ary Frequency Shift Keying, Performance analysis of M-ary modulation schemes under AWGN channel, Non-coherent detection of M-ary orthogonal signals, Carrier and timing recovery, Synchronization, Applications.

Module:6	**Trellis and Turbo Codes**	**4 hours**
Convolutional codes, Viterbi Decoder for convolutional codes, Set partitioning, Trellis codes, Turbo encoders, Turbo decoders, MAP decoder and Max-Log-Map decoder, Irregular and Asymmetric turbo codes.		
Module:7	**LDPC Codes**	**4 hours**
Regular LDPC codes, Gallager construction of LDPC codes, Gallager based decoding algorithm for LDPC codes and its analysis, LDPC threshold, Irregular LDPC codes.		
Module:8	**Contemporary issues:**	**2 hours**
	Total lecture hours:	**30 hours**

Text Book(s)		
1.	Simon S. Haykin, Michael Moher, Communication Systems, 2012, 5th Edition, Wiley, India.	
2.	Shu Lin, Daniel J. Costello, Error Control Coding, 2011, 2nd Edition, Pearson Education, UK.	
Reference Books		
1.	Marvin K. Simon, Sami M. Hinedi, William C. Lindsey, Digital Communication Techniques: Signal Design and Detection, 2015, 1st Edition, Pearson Education, India.	
2.	Richard J. Tervo, Practical Signals Theory with MATLAB Applications, 2013, 1st Edition, Wiley, India.	
3.	http://nptel.ac.in/courses/117101051/	
Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)		
List of Challenging Experiments (Indicative)		
1.	Simple digital communication system: Simulate a simple communication system which transmits a text message from the source to the destination. Also, observe signals at different points of this communication system.	4 hours
2.	Line Coding: Write a code which uses the below mentioned line coding techniques to generate the baseband signal for the given text message. Also, transmit the generated base band signal through AWGN channel. Analyse the effect of channel noise on the reconstructed signal. (a) Unipolar (b) Polar (c) Bipolar (d) Differential coding (Mark and Space)	4 hours
3.	Bandpass Modulation: Write a code which uses below mentioned band pass modulation techniques to generate the modulated signal for the given text message. Transmit the modulated signal through AWGN channel. Detect the transmitted message using the suitable rules. Plot the necessary graphs. (a) BASK (b) BPSK (c) BFSK (d) DPSK	4 hours
4.	Probability of error analysis (a) Consider a bit sequence of length 10,000. Modulate it with BPSK, BASK, BFSK. Transmit the signal through AWGN channel. Vary the SNR. Compare the theoretical and simulated probability of error. (b) Consider a bit sequence of length 10,000. Modulate it with BPSK, QPSK and 8-PSK. Transmit the signal through AWGN channel. Vary	6 hours

	the SNR. Compare the theoretical and simulated probability of error. (c) Consider a bit sequence of length 10,000. Modulate it with 16-QAM and 64-QAM. Transmit the signal through AWGN channel. Vary the SNR. Compare the theoretical and simulated probability of error. (d) Consider a bit sequence of length 10,000. Modulate it with MSK. Transmit the signal through AWGN channel. Vary the SNR. Compare the theoretical and simulated probability of error.	
5.	Channel coding (a) Write a code to build the (3, 1, 3) repetition encoder. Map the encoder output to BPSK symbols. Transmit the symbols through AWGN channel. Investigate the error correction capability of the (3, 1, 3) repetition code by comparing its BER performance with and without using error correction code. (b) Write a code to compare the BER performance and error correction capability of (3, 1, 3) and (5, 1, 5) repetition codes. Assume BPSK modulation and AWGN channel. Also, compare the simulated results with the theoretical results. (c) Write a code to compare the performance of hard decision and soft decision Viterbi decoding algorithms. Assume BPSK modulation and AWGN channel. (d) Write a code to perform Trellis coded modulation for M-QAM and M-PSK systems using Ungerboeck set partitioning principle.	6 hours
6.	Digital Modulation using Simulink: Build the transceiver chain for the following modulation schemes with Simulink. Observe signals at different points of communication system. (a) M-PAM (b) M-PSK (c) M-QAM	6 hours
	Total laboratory hours	**30 hours**
Mode of evaluation: Continuous Assessment & Final Assessment Test (FAT)		
Recommended by Board of Studies	13-12-2015	
Approved by Academic Council	No. 40	Date 18-03-2016

Course Code	Course Title	L	T	P	J	C
ECE5011	Advanced Digital Signal Processing	2	0	2	4	4
Pre-requisite	Nil	Syllabus version				
		1.0				

Course Objectives:

1. To build advanced concepts in digital signal processing applicable for processing and analyzing random process.
2. To familiarize with Signal Modelling and development of recursion techniques.
3. To design optimal filters using IIR and FIR filtering techniques.
4. To acquaint the students with contemporary use and build DSP systems for real time problems.

Course Outcomes:

1. Interpret the random processes in terms of stationarity, statistical independence and correlation.
2. Evaluate the theoretical and practical aspects of signal modelling based on computer algorithms.
3. Apply the mathematical concepts to design effective lattice system for random signal processing.
4. Design and implement the optimum filters using Weiner and Kalman techniques.
5. Extend the concepts of adaptive algorithms to non- stationary signals.
6. Apply different algorithms for computation of power spectral density for the random signals.
7. Solve the real time signal processing problems either with application of programming skills/ hardware kit.
8. Design and implement advanced signal processing systems using the imbibed enhanced signal processing concepts

Module:1	Introduction	5 hours

Discrete-Time Signal Processing: Discrete-Time Signals, Discrete-Time Systems, Time-Domain Descriptions of LSI Filters, Discrete-Time Fourier Transform, and z-Transform, Special Classes of Filters, Filter Flow graphs, The DFT and FFT. Linear and Circular convolution.

Module:2	Discrete Time Random Processes	5 hours

Random Variables: Definitions, Ensemble Averages, Jointly Distributed Random Variables, Joint Moments, Independent, Uncorrelated and Orthogonal Random Variables, Linear Mean Square Estimation, Gaussian Random Variables Parameter Estimation: Bias and Consistency.

Random Processes: Review, auto-covariance and autocorrelation Matrices, Ergodicity, White Noise, Power Spectrum, Filtering Random Processes, Spectral Factorization.

Special Types of Random Processes: Autoregressive Moving Average Processes, Autoregressive Processes, Moving Average Processes, Harmonic Processes.

Module:3	Signal Modelling	4 hours

Introduction, The Least Squares (Direct) Method, The Pad'e Approximation, Prony's Method-Pole-Zero Modeling, Shank's Method. Stochastic Models: Autoregressive Moving Average Models, Autoregressive Models, Moving Average Models

Module:4	The Levinson –Durbin Recursion	3 hours

The Levinson-Durbin Recursion: Development of the Recursion, The Lattice Filter, Properties

Module:5	**Optimal filters**	**4 hours**
The FIR Wiener Filter: Filtering, Linear Prediction, Noise Cancellation, Lattice Representation for the FIR Wiener Filter. The IIR Wiener Filter: Non-causal IIR Wiener Filter, The Causal IIR Wiener Filter, Causal Wiener Filtering, Causal Linear Prediction, Wiener Deconvolution.		
Module:6	**Introduction Adaptive Filters**	**3 hours**
Discrete Kalman Filter, steepest descent algorithm, LMS, RLS		
Module:7	**Spectrum Estimation**	**4 hours**
Non Parametric Methods Periodogram, The Modified Periodogram, Bartlett's Method, Welch's Method, Blackman-Tukey Approach: Periodogram Smoothing, Performance Comparisons. Parametric Methods- Autoregressive Spectrum Estimation, Moving Average Spectrum Estimation, Autoregressive Moving Average Spectrum Estimation.		
Module:8	**Contemporary issues:**	**2 hours**
	Total lecture hours:	**30 hours**

Text Book(s)	
1.	Mitra, Sanjit Kumar, Yong hong Kuo, Digital signal processing: a computer-based approach, 2013, 4th Edition, McGraw-Hill, New York.
2.	Monson H. Hayes, Statistical digital signal processing and modeling, 2012, 1st Edition, Wiley, India.
Reference Books	
1.	Richard G. Lyons, Understanding digital signal processing, 2011, 3rd Edition, Pearson Education, India.
2.	http://freevideolectures.com/Course/3042/Advanced-Digital-Signal-Processing
Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)	

List of Challenging Experiments (Indicative)		
1.	Real time experiments using TMS6713 Processor (a) Interfacing a function generator with TMS 6713 Processor through codec with sampling rate of 96 KHz and display of the signal as a graph in CC-Studio in a time window of 256 samples. (b) Interfacing a function generator with TMS 6713 Processor through codec with sampling rate of 96 KHz and display of the magnitude spectrum of signal as a graph in CC-Studio for a time window of 256 samples by applying FFT for the samples. (c) FIR-filtering (low/high/bandpass) of an audio input obtained through microphone interface and output the result in the loud speaker. (d) IIR-filtering (low/high/bandpass) of an audio input obtained through microphone interface and output the result in the loud speaker.	10 hours
2.	Simulation Experiments using Matlab (a) Decimation and Interpolation of Band limited speech signal and frequency domain analysis. (b) Generation of various Random Processes MA, AR, ARMA. (c) Implementation of FIR and IIR Wiener Filter for separating the desired signal corrupted by AWGN and MSE calculation. (d) Implementation of digital Kalman filter.	20 hours

	(e) ECHO Cancellation. (f) Power spectrum estimation parametric method. (g) Power spectrum estimation non parametric method. (h) Implementation of Adaptive filter using LMS recursive algorithm.	
	Total laboratory hours	**30 hours**

Recommended by Board of Studies	13-12-2015		
Approved by Academic Council	No. 40	Date	18-03-2016

Course Code	Course Title	L	T	P	J	C
ECE5012	Advanced Antenna Engineering	3	0	2	0	4
Pre-requisite	Nil	Syllabus version				
		1.1				

Course Objectives:

1. To provide the essential knowledge of the antenna parameters and measurements.
2. To design antenna array using synthesize techniques.
3. To design the single element microstrip antenna and array with feeder network
4. To introduce the types of high impedance surface antennas for various applications.

Course Outcomes:

1. Understand the radiation mechanism of antenna and to solve the numerical problems related to antenna parameters.
2. Design and interpret non uniform excitation coefficients using array synthesis techniques for minimum side lobe level.
3. Design and analyze rectangular and circular microstrip antenna with power divider network.
4. Understand the importance of defected ground structures and metamaterial surfaces and design high impedance surfaces.
5. Exploit the antennas for wireless communication and radar applications.
6. Comprehend the working of antenna for Software defined and cognitive radio.
7. Acquire knowledge on different computational techniques.

Module:1	Antenna Fundamentals	7 hours

Radiation Mechanism, antennas used in various applications and selection criteria, Antenna measurements using anechoic chamber - Radiation pattern, Radiation Intensity, Power gain, Directivity, impedance, Radiation efficiency, Polarization

Module:2	Antenna Array Synthesis	8 hours

Fourier Transform - Woodward-Lawson Sampling - Schelkunoff Method- Dolph-Tchebyscheff - Taylor Line Source Method

Module:3	Microstrip Antennas	6 hours

Basic characteristics, feeding methods, Methods of analysis – Transmission line model and cavity model - Design of Rectangular patch, Circular patch –Microstrip antenna array and feed network.

Module:4	Antenna Design Techniques	6 hours

Antenna Design using Artificial Impedance Surface Metamaterial- Electromagnetic Band Gap- Defective Ground Structure - High Impedance Surface

Module:5	Antenna Applications –I	6 hours

Integrated Antenna for wireless personal communication, mobile communication- Antenna design consideration for MIMO diversity systems - medical therapy

Module:6	Antenna Applications- II	6 hours

Antenna for Software Defined Radio – Cognitive Radio- Electronic Warfare- Ground penetrating Radar

Module:7	Computational Electromagnetic for Antennas	4 hours

Method of moments (MoM), Finite element method (FEM), Finite difference time domain method

(FDTD)		
Module:8	**Contemporary issues:**	**2 hours**
	Total lecture hours:	**45 hours**

Text Book(s)	
1.	C.A. Balanis, Antenna Theory: Analysis and Design, 2016, 4th edition, Wiley, India
2.	C.A. Balanis, Modern Antenna Handbook, 2012, 1st Edition, Wiley, India
Reference Books	
1.	W.L. Stutzman and G.A. Thiele, Antenna Theory and design, 2012, 3rd Edition, Wiley, India
2.	J. D. Kraus, Antennas and Wave propagation, 2012, 4th Edition, McGraw Hill, India.
3.	Sanjay Kumar, Saurabh Shukla, Wave Propagation and Antenna Engineering, 2016, 1st Edition PHI, India
4.	www.antenna-theory.com
Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)	

List of Challenging Experiments (Indicative)		
1.	Finding the impedance of planar and non-planar antennas (Horn, micro strip, parabolic dish etc.)	4 hours
2.	Design and perform the electromagnetic simulation of dipole and monopole antenna for wireless communication system.	4 hours
3.	Characterization of non-planar and planar Ultra-Wideband antenna and perform the electromagnetic simulation.	4 hours
4.	Design and perform the electromagnetic simulation of planar inverted F-antenna and calculate the SAR performance for mobile hand held devices.	5 hours
5.	Design and development of micro strip patch antenna for WLAN and Bluetooth applications.	4 hours
6.	Antenna array design using Matlab • Taylor series method • Fourier Transform method	5 hours
7.	Measurement of antenna radiation pattern and characterization of polarization properties of antenna	4 hours
	Total laboratory hours	**30 hours**
Mode of evaluation: Continuous Assessment & Final Assessment Test (FAT)		

Recommended by Board of Studies	28-02-2016		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
ECE5013	Fiber Optic Communication and Networks	2	0	2	0	3
Pre-requisite	Nil	Syllabus version				
		1.0				

Course Objectives:

1. To acquaint the basic concepts of active and passive devices and its application in fiber optic networks.
2. To introduce the different types of optical amplifiers SOA, EDFA and RA with respect to operation principle and its applications.
3. To familiarize the theory of non-linearity and optics of anisotropic media and about the nonlinear effects like SRS, SBS, SPM, XPM, FWM and Solitons.
4. To introduce modulators like Electro optic and Acousto optic modulators used in optical transmission

Course Outcomes:

1. Apply the active, passive devices and optical amplifiers in optical networks.
2. Understand how nonlinear effects like SRS, SBS, SPM, XPM, FWM and Solitons can be used in optical fiber communications.
3. Explain the difference between modulators like Electro optic and Acousto optic modulators used in optical transmitters.
4. Analyze the receiver sensitivity and receiver noise, BER and eye pattern.
5. Determine Power and Rise time budgets and understand the different topologies of optical networks, WDM technology, CDMA and SCM.
6. Understand the SONET and Fiber to the home networks.
7. Design, analyze and evaluate fiber optical communication links

Module:1	Network Elements	4 hours

Optical and photonic device technology: Couplers, isolators, circulators, multiplexers and filters, active and passive optical switches, optical cross connects, wavelength selective cross connects, wavelength converters, filters: dielectric, AWG and fiber Bragg grating (FBG) devices, nonlinear optical fibers

Module:2	Optical Amplifiers	2 hours

SOA, EDFA, Raman amplifier

Module:3	Nonlinear Effects	4 hours

Phenomenological theory of nonlinearities, optics of anisotropic media, harmonic generation, mixing and parametric effects, two-photon absorption, saturated absorption and nonlinear refraction. Rayleigh, Brillouin and Raman scattering, self-focusing and self-phase-modulation, cross phase modulation, four-wave mixing, solitons.

Module:4	Optical Modulators	2 hours

Electro-optic effect and acousto optic effects, EO and AO modulators.

Module:5	Detection and receiver design	4 hours

Receiver sensitivity, bit error rate, eye pattern, minimum received power, quantum limit of photo detection. Receiver design: Front end, linear channel, decision circuit, integrated receivers. Noise in detection circuit: shot noise, thermal noise, concept of carrier to noise analysis.

Module:6	**Network Architectures, Topologies and Multi-Channel Systems**	**6 hours**
The end to end transmission path, loss and dispersion budgets in network designing, optical signal flow and constraints, design of star, bus, mesh and ring topologies, multiplexing and multiple access schemes: TWDM/MA, sub carriers, CDMA, capacity allocation for dedicated connections, demand assigned connections.		
Module:7	**Optical Networks**	**6 hours**
Optical networks architecture, SONET/SDH optical network, WDM optical networks, wavelength-routed optical network, routing algorithms, network monitoring and management, fault and security management, routing protocols, intelligent optical network (ION), FDDI, FTTH, business drivers for next-generation optical networks.		
Module:8	**Contemporary issues**	**2 hours**
	Total lecture hours:	**30 hours**

Text Book(s)	
1.	Gerd Keiser, Optical Fiber Communications, 2013, 5th Edition, McGraw-Hill, India.
2.	Cvijetic, M., Djordjevic. I. B., Advanced Optical Communication Systems and Networks, 2013, 1st Edition, Artech House, London.
Reference Books	
1.	R. Ramaswami, K.N. Sivarajan, Morgan Kaufmann, Optical Networks A practical perspective, 2013, 2nd Edition, Pearson Education, India.
2.	G. P Agrawal, Fiber Optic Communication Systems, 2012, 4th Edition, Wiley, India.
3.	C. Siva Ram Murthy, Mohan Gurusamy, WDM optical networks concepts design and algorithms, 2015, 1st Edition, Pearson Education, India.
4.	G. P. Agrawal, Nonlinear Fiber Optics, 2012, 5th Edition, Academic Press, US.
5.	John M Senior, Optical Fiber Communication – principle and practices, 2014, 3rd Edition, PHI, India.
6.	Ivan Kaminov, Tingye Li, Alan E.Wilner, Optical Fiber Telecommunications VI B Systems and Networks, 2013, 6th Edition, Academic Press, India.
7.	http://gogotraining.com/training/courses/20/fiber-optic-communications/

Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)

List of Challenging Experiments (Indicative)		
1.	Fiber non-linear effects – Four-wave mixing, Stimulated Brillouin Scattering	4 hours
2.	Dense wavelength division multiplexing with RAMAN amplifier	3 hours
3.	Ring network Topology with OADM	3 hours
4.	Radio over fiber	4 hours
5.	Free space optical communication link	4 hours
6.	WDM Fiber optic link	4 hours
7.	Power budgeting of an optical fiber link	4 hours
8.	Rise time budgeting of an optical fiber link	4 hours
	Total laboratory hours	**30 hours**

Mode of evaluation: Continuous Assessment & Final Assessment Test (FAT)

Recommended by Board of Studies	13-12-2015		
Approved by Academic Council	No. 40	Date	18-03-2016

Programme Electives

Course Code	Course Title	L	T	P	J	C
ECE6010	High Performance Communication Networks	3	0	0	0	3
Pre-requisite	Nil	Syllabus version				
		1.1				

Course Objectives:

1. To familiarize with OSI, TCP/IP reference model and various high speed networks.
2. To understand the protocols as well as design and performance issues associated with the functioning of LANs and WLANs.
3. To introduce Quality of Service protocols and their importance in analysing network performance.

Course Outcomes:

1. List and explain the functions of the OSI, TCP/IP reference models.
2. Understand and analyze the performance of various high speed networks.
3. Explain the importance of various congestion and traffic management techniques related to packet switching networks
4. Understand and analyze the performance of link level protocols.
5. Analyze the behavior of TCP and UDP protocols over WLAN.
6. Understand the performance of queuing models and issues related to QoS protocols.

Module:1	Network Services and Layered Architectures	8 hours

Networking principles, Applications, Traffic characterization, Network elements, Basic network mechanisms, Open data network model, OSI, TCP, UDP and IP Models, Network architectures, Network bottlenecks.

Module:2	High Speed Networks	8 hours

Packet switching networks, Frame relay networks, ATM, High speed LAN, Ethernet, WLAN, DWDM, OBS, OPS.

Module:3	Congestion and Traffic Management	6 hours

Congestion control in data networks, Effects of congestion, Traffic management, Congestion control in packet switching networks

Module:4	Link level Flow, Error and Traffic Control	7 hours

Need for flow and error control, Link control mechanisms, ARQ performance, TCP flow and congestion control.

Module:5	UDP-TCP/IP Protocol Stack over WLAN Network	6 hours

UDP behaviour over WLAN, Effect of access based on RTS/CTS, Behaviour of TCP over WLAN, Influence of errors in UDP and TCP.

Module:6	Integrated and Differentiated Services	4 hours

Integrated Services Architecture (ISA), Queuing discipline, Random early detection, Differentiated services.

Module:7	Quality of Service Protocols	4 hours

Protocol for QoS support, Resource reservation: RSVP, MPLS, Real Time Transport Protocol,

Self-Configuring techniques, Multichannel protocols.			
Module:8	**Contemporary issues**		**2 hours**
	Total lecture hours:		**45 hours**
Text Book(s)			
1.	William Stallings, High-speed Networks and Internets, 2012, 2nd Edition, Pearson Education, United Kingdom.		
2.	Jean Warland, Pravin Varaiya, High Performance Communication Networks, 2011, 2nd Edition, Harcourt and Morgan Kauffman Publishers, London.		
Reference Books			
1.	Leon Gracia, Widjaja, Communication Networks, 2011, 1st Edition, McGraw Hill, New York, USA.		
2.	Ramjee Prasad, Luis Munoz, WLANs and WPANs Towards 4G Wireless, 2013, 1st Edition, Artech House, London.		
3.	http://www.2.ensc.sfu.ca\~ljilja\ensc835\fall03\		
Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)			
Recommended by Board of Studies	28-02-2016		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
ECE6011	Mobile Adhoc Networks	3	0	0	0	3
Pre-requisite	Nil	Syllabus version				
		1.1				

Course Objectives:

1. To acquaint the fundamental of adhoc wireless networks and cellular networks.
2. To design contention-based MAC protocols and routing protocols for adhoc networks.
3. To recognize the QoS frameworks, network security issues, energy management and paraphrase the mobile adhoc network towards WSN, VANET, WPAN.

Course Outcomes:

1. Comprehend and analyze the deployment consideration and issues in adhoc network.
2. Classify the contention-based MAC protocols based on reservation and scheduling mechanism.
3. Compute the routing table for unicast routing protocols.
4. Comprehend and analyze the multicast routing protocols.
5. Recognize the quality of service solutions, security issue and energy management in adhoc networks.
6. Comprehend and analyze the architecture and data processing of wireless sensor network.

Module:1	Introduction	6 hours

Introduction to Cellular and Ad hoc wireless networks, Applications of ad hoc networks, Issues in ad hoc wireless networks, Medium access scheme, Routing, Multicasting, Transport layer protocols, Pricing scheme, Quality of Service provisioning, Self-organization, Security, Address and security discovery, Energy management, Scalability, Deployment considerations, Ad hoc wireless Internet

Module:2	MAC Protocols	8 hours

Issues in designing a MAC Protocol for ad hoc wireless networks, design goals of a MAC Protocol for Ad Hoc Wireless Networks, Classification of MAC Protocols, Contention based Protocols, Contention based Protocols with Reservation mechanism, Contention Based MAC Protocols with Scheduling Mechanisms, Other MAC protocols

Module:3	Routing Protocols	8 hours

Design issues and classification, Table-driven, On-demand and Hybrid routing protocols, Routing protocols with efficient flooding mechanisms, Hierarchical and Power-aware routing protocol

Module:4	Multicast Routing Protocols	8 hours

Design issues and operation, Architecture reference model, Classification, Tree-based and Mesh-based protocols, Energy-Efficient multicasting, Multicasting with Quality of Service guarantee, Application dependent multicast routing

Module:5	Quality of Service and Security Issues	4 hours

Issues and challenges in providing QoS, Classification of QoS solutions, MAC layer solutions, Network layer solutions, QoS frameworks, Network security issues

Module:6	Energy Management	4 hours

Need, Classification of battery management schemes, Transmission power management schemes, System power management schemes.

Module:7	**Wireless Sensor Networks**	**5 hours**
Wireless Sensor Networks: Architecture, Data dissemination, Data gathering, MAC Protocols, Location discovery, Quality of a sensor network, Issues and current trends in MANETs, VANETs, WSN, 6LoWPAN		
Module:8	**Contemporary issues**	**2 hours**
	Total lecture hours:	**45 hours**

Text Book(s)	
1.	C. Siva Ram Murthy, B. S. Manoj, Ad-Hoc Wireless Networks: Architectures and Protocols, 2012, 1st Edition, Prentice Hall, New Jersey.
Reference Books	
1.	C-K. Toh, AdHoc Mobile Wireless Networks: Protocols and Systems, 2011, 1st Edition, Prentice Hall, New Jersey.
2.	Mohammad Ilyas, The Handbook of AdHoc Wireless Networks, 2012, 1st Edition, CRC press, Florida.
3.	Minoru Etoh, Next Generation Mobile Systems 3G and Beyond, 2011, 1st Edition, Wiley Publications, New Jersey.
4.	Savo Glisic, Advanced Wireless Communications 4G Technologies, 2013, 1st Edition, Wiley Publications, New Jersey.
5.	http://www.ece.rochester.edu/courses/ECE586/index.htm

Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)			
Recommended by Board of Studies	28-02-2016		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
ECE6012	Modern Wireless Communication Systems	3	0	0	4	4
Pre-requisite	Nil	Syllabus version				
		1.0				

Course Objectives:

1. To introduce the fundamentals and limitations of wireless channels imposed on communication systems.
2. To understand the principles and importance of spread spectrum and multicarrier communication in the context of wireless communication.
3. To identify the role of diversity and MIMO techniques in combating the effect of fading and maximizing the capacity.
4. To cognize the most recent trends in the broad area of wireless communication.

Course Outcomes:

1. Describe the effect of large scale fading on signal transmission
2. Characterize and model the wireless channel in terms of small scale fading parameters
3. Design and implement diversity coding techniques to overcome the effect of fading
4. Apply the theory of probability and random processes in the design of baseband CDMA system
5. Design the transmitter and receiver blocks of OFDM for better transmission through multipath channel
6. Design and solve specific problems in advanced technologies like massive MIMO, HetNet, millimeter wave communication and standards like LTE, LTE-A etc.
7. Design spatial multiplexing schemes and low-complexity receivers to maximize the spectral efficiency

Module:1	Large-Scale Path Loss	6 hours

Propagation of EM signals in wireless channel, Reflection, Diffraction and scattering, Free space propagation model, Two ray ground reflection model, Log-distance path loss model, Log-normal shadowing, Outdoor propagation models, Longley-Rice model, Okumura model, Hata model, COST-231, Link power budget analysis.

Module:2	Small-Scale Fading and Multipath	4 hours

Parameters of mobile multipath channels, Types of small scale fading, Rayleigh and Rician distributions, Jakes Doppler spectrum.

Module:3	Diversity Techniques	5 hours

Condition for deep fading, Probability of error analysis under fading channel, Time diversity, Repetition codes, Frequency diversity, Spatial diversity techniques, Analysis of BER of multi antenna system, Diversity order.

Module:4	Spread Spectrum Techniques	6 hours

Introduction to spread spectrum, Orthogonal spreading codes, Benefits of spreading (Jamming Margin, Graceful degradation, Universal frequency reuse, Multipath diversity), Multi user CDMA, Performance analysis of CDMA downlink with multiple users, Performance analysis of CDMA uplink with multiple users, Asynchronous CDMA, Near far problem, Power control, CDMA receiver synchronization, Introduction to MC-CDMA.

Module:5	OFDM	8 hours
Introduction to multicarrier modulation, Importance of cyclic prefix, Adaptive modulation and coding techniques. OFDM issues, PAPR, Frequency and timing offset, ICI mitigation techniques, Introduction to SC-FDMA-PAPR analysis with localized and interleaved schemes.		
Module:6	**Physical Layer Aspects of LTE and LTE-A**	**5 hours**
Requirements and targets of LTE, Introduction to downlink physical layer design, Transmission resource structure, Synchronization and cell search, Reference signals and channel estimation, Cell specific reference signal generation, UE specific reference signal generation, Downlink physical data and control channels, Link adaptation, Introduction to uplink physical layer design, Carrier aggregation, HARQ, Relaying strategies and benefits.		
Module:7	**MIMO and Recent Trends**	**9 hours**
Spatial multiplexing, Decomposition of MIMO channel, Pre-coding, Optimal MIMO power allocation, MIMO beamforming, Nonlinear MIMO receivers-V-BLAST, D-BLAST, Requirements of 5G, Drawbacks of OFDM, Introduction to Filter Bank Multicarrier System (FBMC), Massive MIMO, Millimeter wave technology, Dense network, Cognitive radio technology, Smart antennas, Multi-hop relay networks.		
Module:8	**Contemporary issues**	**2 hours**
	Total lecture hours:	**45 hours**

Text Book(s)

1. Aditya K. Jagannatham, Principles of Modern Wireless Communications Systems, 2015, 1st Edition, McGraw-Hill Education, India.

Reference Books

1. Simon Haykin, Michael Moher, Modern Wireless Communications, 2011, 1st Edition, Pearson Education, India.
2. http://nptel.ac.in/courses/117104099/

Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)

Typical Projects:

1. Implementation of Jakes Rayleigh fading channel model
2. Consider the following extended vehicular: a channel power delay profile. Write a code to model the given profile. Also, measure the channel capacity. Compare the obtained capacity to that without fading channel.

Delay (ns)	Power (dB)
0	0
30	-1.5
150	-1.4
310	-3.6
370	-0.6
710	-9.1
1090	-7
1730	-12
2510	-16.9

3. Probability of error analysis for higher order modulation schemes under fading channel

4. Inter Carrier Interference (ICI) mitigation in OFDM system 5. Study and analysis of peak to average power ratio (PAPR) reduction schemes in OFDM system 6. Study and analysis of peak to average power ratio (PAPR) using SC-FDMA 7. Channel estimation schemes for OFDM system 8. Study and analysis of beamforming schemes for MIMO system 9. Study and analysis of diversity schemes for MIMO system 10. Implementation of SFBC-OFDM 11. Implementation of antenna selection schemes for MIMO system 12. Study and analysis of channel estimation schemes for MIMO system 13. Design of filters for filter bank multicarrier system 14. Estimation of angle of arrivals in MIMO system 15. Implementation of small cell placement schemes for dense network 16. Implementation of path selection algorithms for multi-hop relay networks 17. Implementation of Maximum likelihood true parameter estimator for wireless sensor networks 18. Implementation spectrum sensing algorithms for cognitive radio 19. Implementation of spectrum handoff algorithms for cognitive radio 20. Study and analysis of CFO estimation algorithms for OFDM systems			
Mode of evaluation: Review I, II and III.			
Recommended by Board of Studies	13-12-2015		
Approved by Academic Council	No. 40	Date	18-03-2016

Course Code	Course Title	L	T	P	J	C
ECE6013	Modeling of Wireless Communication Systems	3	0	2	0	4
Pre-requisite	Nil				Syllabus version	
						1.1

Course Objectives:

1. To understand the necessity of modeling and simulation approach.
2. To provide an introduction to different error sources, impairments and performance metrics.
3. To determine the type and appropriate model of wireless fading channel based on the system parameters and the property of the wireless medium.
4. To understand different queuing models for communication and networking applications.

Course Outcome:

1. Apply simulation approach to evaluate the performance of a communication system
2. Apply the theory of random processes in modelling the wireless communication system
3. Estimate the bit error rate using Monte Carlo simulations and validate the simulations using bounds and approximations
4. Evaluate the performance of communication system in terms of performance metrics like bit error rate, outage probability etc.
5. Model multipath fading channels that are used in the performance analysis of wireless standards like GSM, WCDMA, LTE, Wi-Fi, WiMAX etc.
6. Apply queueing models to design cellular network with given quality of service constraints
7. Design as well as conduct experiments, analyze and interpret the results to provide valid conclusions for wireless communication using MATLAB tool.

Module:1	Introduction to simulation approach	4 hours

Simulation approach, Advantages and limitations, Methods of performance evaluation, Error sources in simulation, Role of simulation in communication systems.

Module:2	Fundamentals of Random Variables and Random Processes for Simulation	6 hours

Introduction to random variables (continuous and discrete), Univariate and Bivariate models, Transformation of random variables, Moments, Central moments, Characteristic function, Moment generating function, Stationarity, Wide sense stationary, Ergodicity, auto correlation, Power spectral density, Cross correlation, Sampling of stationary random processes.

Module:3	Bounds and approximations	3 hours

Chebyshev's inequality, Chernoff bound, Union bound, Central limit theorem, Approximate computation of expected values.

Module:4	Monte Carlo simulations	6 hours

Variations of Monte Carlo Simulation, Random number generation, Generating independent random sequences, Generation of correlated random sequences, Testing of random number generators.

Module:5	System Modeling	8 hours

Modeling the information sources, Source coding, Channel coding, Baseband modulation, Multiplexing, Multiple access, Band pass modulation, Detection, Equalization, Carrier and timing recovery for BPSK and QPSK, Performance analysis of communication system under noisy channel conditions.

Module:6	**Channel Modeling**	**8 hours**
Large scale fading models, Small scale fading models, Types of fading, Parameters characterizing fading, Rayleigh fading, Jakes model, Clarke's model, Path loss models for LTE and Wi-Max networks, Performance analysis of communication systems under fading channel, Performance analysis of communication systems with MIMO.		
Module:7	**Queuing Modeling**	**8 hours**
Markovian models, Basic queuing models, M/G/1 queuing system, Pollaczek-Khinchine formula, Network of queues, Fundamentals of teletraffic theory, blocked call cleared system, blocked call delayed system, Queuing theory for teletraffic modeling.		
Module:8	**Contemporary issues**	**2 hours**
	Total lecture hours:	**45 hours**

Text Book(s)	
1.	William H. Tranter, K. Sam Shanmugan, T. S Rappaport, Kurt L. Kosbar, Principles of Communication System Simulation with Wireless Applications, 2011, 1st Edition, Prentice Hall Press, USA.
2.	M. N. Sadiku, S. M. Musa, Performance Analysis of Computer Networks, 2013, 1st Edition, Springer, Switzerland.
Reference Books	
1.	John G. Proakis, Masoud Salehi, Gerhard Bauch, Contemporary Communication Systems using MATLAB, 2013, 3rd Edition, Nelson Engineering, Canada.
2.	http://web.stanford.edu/class/ee359/lectures.html
3.	http://www.cse.wustl.edu/~jain/cse567-15/index.html
Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)	

List of Challenging Experiments (Indicative)		
1.	Computation of Probability Mass (Density) Function (PMF or PDF) Generate 1000 sample points of real numbers uniformly distributed between '0' and '1'. (a) Let X be Random Variable (RV) taking values '0' &'1'. X=0 corresponds to the sample points whose values are less than 0.5. X=1 corresponds to the sample points whose values are between 0.5 and 1. Draw the probability mass function of the RV, X. (b) Repeat part (i) for RV 'Y' taking values 0, 1&2. 0: sample values between 0 & 1/3 1: sample values between 1/3 & 2/3 2: sample values between 2/3 & 1.	2 hours
2.	Computation of PDF and Cumulative Distribution Function (CDF) (a) Draw the graph for the binomial density function for N=6 and p=0.4. Also, compute and show it by graph, the binomial CDF. (b) The pdf of the Gaussian RV is given as $f_X(x)=\frac{1}{\sqrt{2\pi}}e^{\frac{-x^2}{2}}, -\infty < x < \infty$. Draw $f_X(x)\ -3 < x < 3$ for 'x' in steps of 0.05. Develop and draw the CDF of the above function.	2 hours
3.	Generation of Histogram of Uniform RV (a) Generate 1000 sample points of real numbers uniformly distributed	2 hours

	between 0 & 1. Compute the Histogram of the above sample points (Take 10 uniform steps between 0 & 1). Redraw the histogram when the sample points are increased to 2000. Also observe it when the steps are increased from 10 to 20. Compare your results with built in Matlab function. (b) Generate 1000 samples of a uniform RV taking values between 0 & 2π. Generate the new RV,. Plot the pdf of Y. Compare this with the theoretical result.	
4.	Generation of Histogram of Gaussian RV (a) Redo the steps given in 3 (i) with Matlab function 'rand' replaced by 'randn'. (b) Write a Matlab script to compute the mean, mean square, variance and standard deviation for the RVs given in the tasks 4 & 5 and display them on the command prompt. Compare your results with the built in functions.	4 hours
5.	Transformation of Uniform pdf to exponential and Rayleigh pdfs (a) Generate 1000 sample points of uniform pdf. Use appropriate transformation to convert uniform pdf to (i). exponential pdf (ii). Rayleigh pdf (iii). Draw their corresponding pdf curves. (b) Generate 1000 samples of a 'Gaussian' random variable X. Use the transformation $Y=X^2$. Draw the pdf of Y and compare it with theoretical results. (c) Consider the following: (i). Generate 1000 samples for two independent Gaussian random variables, X and Y with $\mu = 0$ and $\sigma^2 = 1$. Generate new random variables, $Z = \sqrt{X^2 + Y^2}$ and $\theta = \text{Tan}^{-1}\left(\frac{Y}{X}\right)$. Draw their pdfs and compare with the theoretical results. (ii). Now add a constant value of 5 to the samples of R.V., X and solve the above problem again.	4 hours
6.	Baseband Transmission and Reception schemes: (a) Spectral analysis of various line coding techniques (b) Implementation of matched filter receiver (c) Pulse shaping with Raised cosine and square root raised cosine filters (d) Implementation of LMS adaptive equalizer for ISI mitigation	6 hours
7.	Band-pass Transmission and Reception schemes: (a) BER, capacity and outage analysis of different modulation schemes (theoretical and simulated) (b) Maximum likelihood detector design for higher order modulation schemes	4 hours
8.	Error correction coding: (a) Coding gain comparison between different codes (b) Time diversity with repetition codes (c) Turbo encoder design	3 hours
9.	Multiple Access schemes: (a) OFDMA Transceiver chain (b) SC-FDMA Transceiver chain	3 hours

		Total laboratory hours	**30 hours**
Mode of evaluation: Mode of evaluation: Continuous Assessment & Final Assessment Test (FAT)			
Recommended by Board of Studies	28-02-2016		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
ECE6014	Modern Satellite Communication	3	0	0	0	3
Pre-requisite	Nil	Syllabus version				
		1.0				

Course Objectives:

1. To exemplify in depth knowledge of Satellite communication system.
2. To have a detailed understanding of the critical RF parameters in satellite transceiver and their effects on performance.
3. To have a detailed understanding of the fundamental theory and concepts of the Global Positioning and inertial navigation System.

Course Outcomes:

1. Design the orbital and functional metrics of satellite communication systems.
2. Design the link budget for satellite services and analyze various parameters of transmitted and received signals through satellite.
3. Analyze user position using GPS pseudo-range data and error sources for GPS position calculations.
4. Analyze strap down inertial navigation systems including coordinate frames, attitude representation, and mechanization in various coordinate frame.
5. Develop a location based service using external data sources and services, web mapping and aspects of mobile technology.
6. Analyze the estimation techniques for integration of remote sensing sensors in an optimal navigation system.

Module:1	Introduction to Satellite Communication	7 hours

Overview of satellite communications, Types of satellites, Kepler's three laws of planetary motion, Orbital elements, Look angle determination, Orbital pert

Module:2	Launch and Satellite Systems	6 hours

Launch vehicles, Launching techniques, Orbital effects in satellite communication systems performance, Satellite subsystems, Satellite constellations

Module:3	Global Navigation Satellite System	7 hours

Global Navigation Satellite Systems, Basic concepts of GPS, Space segment, Control segment, user segment, GPS constellation, GPS measurement characteristics, Selective availability, Anti spoofing (AS). Applications of satellite and GPS for 3D position, Velocity, determination as function of time, Regional navigation systems

Module:4	Inertial Navigation	7 hours

Introduction to Inertial Navigation, Inertial sensors, Navigation coordinates, System implementations, System, Level error models, introduction to Differential GPS, LADGPS, WADGPS, WAAS, GEO Uplink Subsystem (GUS), Clock steering algorithms, GEO orbit determination

Module:5	Location Applications	2 hours

Distress and safety, Cospas, Sarsat, Inmarsat distress system, Location-based service, Problems

Module:6	Sensors, Remote Sensing Systems and Techniques	8 hours

Overview of sensors, Optical sensors: cameras, Non-Optical sensor, Image processing, Image

interpretation, System characteristics. Introduction to remote sensing systems, Commercial imaging, Digital globe, GeoEye, Meteorology, Meteosat, Land observation, Landsat, Remote sensing data		
Module:7	**Broadcast Systems**	**6 hours**
Introduction, Satellite radio systems, XM satellite radio inc., Sirius satellite radio, World space, Direct multimedia broadcast, MBCO and TU multimedia, European initiatives, Direct To Home (DTH) television, Implementation issues, DTH Services, representative DTH Systems, Military multimedia broadcasts, US Global Broadcast Service (GBS), Business TV(BTV), GRAMSAT, Specialized services, Email, Video conferencing, Internet.		
Module:8	**Contemporary issues**	**2 hours**
	Total lecture hours:	**45 hours**

Text Book(s)	
1.	Mohinder S. Grewal, Lawrence R. Weill, Angus P. Andrews, Global Positioning Systems, Inertial Navigation, and Integration, 2011, 1st Edition, John Wiley & Sons, New Jersey.
2.	T. Pratt, C.W. Boastian, Jeremy Allnutt, Satellite Communication, 2013, 2nd Edition, John Wiley & Sons, New Jersey.
Reference Books	
1.	Madhavendra Richaria, Mobile Satellite Communications: Principles and Trends, 2014, 2nd Edition, John Wiley & Sons, New Jersey.
2.	D. Roddy, Satellite Communications, 2011, 4th Edition, McGraw Hill, New York.
3.	W.L. Pritchard, H.G Suyderhoud, Satellite Communication Systems Engineering, 2011, 2nd Edition, Pearson Education, United Kingdom.
4.	Tri T. Ha, Digital Satellite Communications, 2011, 2nd Edition, McGraw Hill, New York.
5.	http://www.satcom.co.uk/

Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)			
Recommended by Board of Studies	13-12-2015		
Approved by Academic Council	No. 40	Date	18-03-2016

Course Code	Course Title	L	T	P	J	C
ECE6015	Coding for MIMO Communication	3	0	0	0	3
Pre-requisite	Nil	Syllabus version				
		1.1				

Course Objectives:

1. To understand the importance of MIMO for next generation networks.
2. To identify the role of different diversity formats and spatial multiplexing in combating the effect of fading and maximizing transmission capacity.
3. To provide an introduction to advanced MIMO concepts like multi-user MIMO, massive MIMO and SM-MIMO for next generation communication.

Course Outcomes:

1. Characterize and model the MIMO wireless channel
2. Design and implement diversity coding techniques to overcome the effect of fading
3. Design optimal power allocation algorithms to maximize the system capacity
4. Assemble different forms of diversity to improve the error performance
5. Design low-complexity, linear and non-linear receivers
6. Evaluate the performance of concatenated codes for MIMO communication

Module:1	Introduction to MIMO and Wireless Channel	6 hours

Introduction, Multi antenna systems, Array gain, Diversity gain, Data pipes, Spatial multiplexing, Wireless channel, MIMO system model.

Module:2	Diversity Techniques	6 hours

Diversity, Types, Selection diversity, Scanning diversity, Maximum ratio combining, Equal gain combining, Calculation of SNR.

Module:3	Capacity of MIMO Channel	6 hours

MIMO system capacity, Channel unknown to the transmitter, Channel known to the transmitter, Water pouring principle, Capacity when channel is known to the transmitter, Deterministic channels.

Module:4	Space Time Block Coding	6 hours

Transmit diversity with two antennas: Alamouti scheme, STBC for real signal constellation, STBC for complex signal constellation, Decoding of STBC-OSTBC, Capacity of OSTBC.

Module:5	Space Time Trellis Codes	7 hours

Space Time Coded system, Design of space time trellis coded on slow fading channel, Error probability of slow fading channel, Design of space time trellis codes on fast fading channels, Error probability of fast fading channels, Comparison of STBC and STTC.

Module:6	Layered Space Time Codes	6 hours

LST transmitters: Types of encoding, Horizontal encoding, Vertical encoding, Diagonal encoding, Layered Space-Time coding design criteria, Performance analysis of HLST, VLST and DLST systems, Code design criteria, Receivers for LST systems, Iterative receivers.

Module:7	Concatenated Codes and Iterative Decoding	6 hours

Development of concatenated codes, Concatenated codes for AWGN and MIMO channels, Turbo coded modulation for MIMO channels, Concatenated space-time block coding.

Module:8	**Contemporary issues:**	**2 hours**
	Total lecture hours:	**45 hours**

Text Book(s)	
1.	Aditya K. Jagannatham, Principles of Modern Wireless Communications Systems, 2015, 1st Edition, McGraw-Hill Education, India.
Reference Books	
1.	A. B. Gershman, N. D. Sidiropoulus, Space-time Processing for MIMO Communications, 2011, 1st Edition, Wiley, NJ, USA.
2.	A. Paulraj, R. Nabar, D Gore, Introduction to Space-Time Wireless Communications, 2013, 1st Edition, Cambridge University Press, UK.
3.	Tolga M. Duman, Ali Ghrayed, Coding for MIMO Communication Systems, 2012, 1st Edition, John Wiley & Sons, West Sussex, England.
4.	http://nptel.ac.in/syllabus/syllabus.php?subjectId=117104118

Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)			
Recommended by Board of Studies	28-02-2016		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
ECE6016	Advanced Wireless Sensor Networks	2	0	2	0	3
Pre-requisite	Nil	Syllabus version				

Course Objectives:

1. To gain knowledge in physical, MAC and routing layers of WSN (Wireless Sensor Networks).
2. To learn WSN standards.
3. To analyze the performance of WSN

Course Outcomes:

1. Understand the Architectures of WSNs.
2. Design Physical and MAC Layers.
3. Design Network layer in WSN.
4. Understand Clustering in WSN.
5. Interpret WSN Standards.
6. Design Localization process in WSN.
7. Understand and write code for Operating Systems in WSN.

Module:1	**Architectures of WSNs**	**3 hours**

Challenges and enabling technologies for Wireless Sensor Networks, Single-Node architecture, Hardware components, Energy consumption of sensor node, Sensor network scenarios

Module:2	**Physical and MAC Layers**	**5 hours**

Physical layer and transceiver design considerations in WSNs, MAC Protocols for WSNs: Schedule-based protocols, Random Access-based protocols, Sensor-MAC: Periodic listen and sleep operations, Schedule selection and coordination, Schedule synchronization, Adaptive listening, Access control and data exchange, Message passing.

Module:3	**Network layer in WSN**	**4 hours**

Challenges for routing, Data centric and flat architecture

Module:4	**Clustering in WSN**	**4 hours**

Hierarchical protocols, Geographical routing, QoS based protocols

Module:5	**WSN Standards**	**4 hours**

802.15.4 - PHY and MAC, Zigbee, 6LoWPAN

Module:6	**Localization in WSN**	**4 hours**

Challenges in localization, Ranging techniques, Range-based localization, Range-free localization.

Module:7	**Operating Systems in WSN**	**4 hours**

Introduction, WSN - operating system design issues, Examples of OS, TinyOS.

Module:8	**Contemporary issues**	**2 hours**
	Total lecture hours:	**30 hours**

Text Book(s)

1. Holger Karl, Andreas Wiilig, Protocols and Architectures for Wireless Sensor Networks,

	2011, 1st Edition, John Wiley & Sons, New Jersey.			
2.	Kazem Sohraby, Daniel Minoli, Taieb Znati, Wireless Sensor Networks-Technology, Protocols, and Applications, 2012, 1st Edition, John Wiley & Sons, New Jersey.			
Reference Books				
1.	Ian F. Akyildiz, Mehmet Can Vuran, Wireless Sensor Networks, 2011, 1st Edition, John Wiley & Sons, New Jersey.			
2.	Anna Hac, Wireless Sensor Network Designs, 2013, 1st Edition, John Wiley & Sons, New Jersey.			
3.	http://ebooks.cambridge.org/ebook.jsf?bid=CBO9781139030960			
Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)				
List of Challenging Experiments (Indicative)				
1.	Design of wireless sensor node and the components of a WSN.			2 hours
2.	Design of WSN for transmission and reception of data using two or more sensors.			2 hours
3.	Understand the role of a transceiver and analyze the effect of transmission range and antenna power level on the residual energy of a sensor node.			3 hours
4.	Design of range based localization techniques.			3 hours
5.	Design and demonstrate the role of duty cycle (sleep/wakeup) in determining the power consumption of a sensor node.			3 hours
6.	Analyze the effect of variable sensing rates and data transmission rate on the power consumption of a sensor node.			3 hours
7.	Performance analysis of CSMA/ CA (slotted, Un-slotted) MAC protocol.			3 hours
8.	Investigate the use of various real world sensors (Temperature, Humidity, light intensity, rain gauge etc.) and demonstrate the data acquisition from a sensor.			3 hours
9.	Design and analyze WSN algorithms for clustering of sensor nodes. Also, evaluate static clustering technique with respect to WSN life time and throughput.			4 hours
10.	Design and demonstrate the role of Gateways in inter cluster/cluster to sink data transmissions. Design and analyze the performance of any two routing techniques prescribed for WSN architecture (Energy aware routing- Location based routing: GF, GAF, GEAR, GPSR, Attribute based routing–Directed diffusion, Rumor routing, Geographic hash tables)			4 hours
			Total laboratory hours	**30 hours**
Mode of evaluation: Continuous Assessment & Final Assessment Test (FAT).				
Recommended by Board of Studies	13-12-2015			
Approved by Academic Council	No. 40	Date	18-03-2016	

Course Code	Course Title	L	T	P	J	C
ECE6017	RF and Microwave Circuit Design	2	0	2	4	4
Pre-requisite	Nil	Syllabus version				
		1.0				

Course Objectives:

1. To have the essential knowledge of high frequency parameters.
2. To familiarize the student with concept of high frequency network analysis and design.
3. To have the ability to design microwave passive and active networks.
4. To get acquitted with emerging trends in microwave IC design concepts.

Course Outcomes:

1. Explain the active & passive microwave devices & components used in Microwave communication systems.
2. Analyze microwave networks with S-parameters.
3. Design power dividers and low pass filters.
4. Analyze the multi- port RF networks, RF transistor amplifiers and stability.
5. Generate Microwave signals and design microwave amplifiers.
6. Understand the concepts of Microwave Resonators, Oscillators and Mixers.
7. Able to implement applications of microwave circuits through soft-ware and hard-ware platforms.
8. Able to understand the IEEE standards, research papers, replicate and extend those results.

Module:1	Microwave Fundamentals	4 hours

Microwave frequencies (IEEE Standards), Smith Chart: Basic impedance & admittance chart, calculation of VSWR, Reflection coefficient, design of impedance matching circuits using lumped elements and distributed elements.

Module:2	Microwave Network Analysis	4 hours

Scattering parameters, S-matrix and properties, S-matrix analysis of two port network with overall input and output reflection coefficients and Signal flow graph. Scattering parameter analysis of 2-port, 3-port and 4-port devices.

Module:3	Microwave Low Pass Filter Design	3 hours

Low Pass Filter design (Butterworth and Chebyshev) - Insertion loss method: Richard's Transformation, Kuroda's identities, Stepped impedance low pass filter.

Module:4	Microwave Transistors and Stability	4 hours

Characteristics of microwave transistors, various types of two port power gains, tests for unconditional stability of an amplifier, stability circles.

Module:5	Microwave Amplifier Design	5 hours

Single stage amplifier design for maximum gain and specific gain, design of low noise amplifiers, characteristics of power amplifiers.

Module:6	Microwave Resonators	3 hours

Transmission line resonators, Waveguide resonators and Dielectric resonators

Module:7	**Microwave Oscillators and Mixers**	**5 hours**
Oscillators: Condition for oscillations in a one port network oscillator and two port network oscillators and oscillator phase noise. Mixer: Characteristics of mixer, image frequency, single ended diode mixer, single ended FET mixer.		
Module:8	**Contemporary issues**	**2 hours**
	Total lecture hours:	**30 hours**

Text Book(s)	
1.	D. M. Pozar, Microwave engineering, 2012, 4th Edition, John Wiley, India.
2.	G. Gonzalez, Microwave Transistor Amplifiers Analysis and Design, 2012, 2nd Edition, Prentice Hall, India
Reference Books	
1.	Reinhold Ludwig, Pavel Bretchko, RF Circuit Design: Theory and Applications, 2014, 1st Edition, Prentice Hall, India.
2.	http://www.microwaves101.com/

Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)

List of Challenging Experiments (Indicative)		
1.	Analysis and Design Equal and Unequal Wilkiason Power division using Electromagnetic Simulation for L and S- Band Applications.	4 hours
2.	Development of Wideband Phase Shifter for L and S band Applications.	3 hours
3.	Design and Development of Microwave Filters. (a) Low Pass Filter (b) Band Pass Filter (c) High Pass Filter	5 hours
4.	Design and Development of Microwave Coupler. (a) Branch line Coupler (90^o hybrid coupler) (b) Rat Race Coupler (180^o hybrid coupler)	5 hours
5.	Design and Development of Microwave Resonators. (a) Half wavelength (b) Quarter Wavelength	5 hours
6.	Design and Perform the Electromagnetic Simulation of High Pass Filter Using Steeped impedance and Richard Transform Method.	4 hours
7.	Design and Analysis of Narrow band Microwave Amplifier for L and S Band applications using Specific Gain and Maximum Gain Method.	4 hours
	Total Laboratory Hours	30 hours

Mode of evaluation: Continuous Assessment & Final Assessment Test (FAT).

Typical Projects:

1. Design & EM simulation of Wilkinson 2-way power divider
2. Design & EM simulation of Wilkinson 4-way power divider.
3. Design & EM simulation of branch line coupler.
4. Design & EM simulation of rat race coupler.
5. Design & EM simulation of quarter wave length microstrip resonators.
6. Design & EM simulation of half wave length microstrip resonators.
7. Design & EM simulation of high pass filter using insertion loss method.

8. Design and analysis of miniaturization techniques for power dividers. 9. Design and analysis of miniaturization techniques for low pass filters.			
Mode of evaluation: Review I, II and III.			
Recommended by Board of Studies	13-12-2015		
Approved by Academic Council	No. 40	Date	18-03-2016

Course Code	Course Title	L	T	P	J	C
ECE6018	Microwave Integrated Circuits	3	0	0	0	3
Pre-requisite	Nil	Syllabus version				
		1.1				

Course Objectives:

1. To have the essential knowledge of various planar microstrip circuits.
2. To design and analyse various types of microwave planar circuits.
3. To acquaint the fabrication techniques and tolerances for MIC circuits.

Course Outcomes:

1. Comprehend the importance of various microstrip lines and the losses due to various microstrip discontinuities.
2. Understand the design of lumped elements for microwave circuits.
3. Design and analyze various microstrip resonators.
4. Design and analyze microstrip power dividers and couplers.
5. Design and analyze band pass filters.
6. Appreciate and evaluate the performance of various fabrication techniques for planar circuits.

Module:1	Planar Transmissions Lines	6 hours

Introduction, types of MICs and their technology, types of planar transmission lines, introduction to coupled microstrip lines, slot lines and co-planar waveguides.

Module:2	Microstrip Lines	6 hours

Fields of propagation in microstrip lines, design equations of microstrip lines (characteristic impedance and W/H relation), losses in microstrip lines, discontinuities in microstrip lines.

Module:3	Lumped elements for MICs	6 hours

Lumped microstrip components: Design of microstrip and chip inductors, capacitors, resistors. Quasi lumped microstrip elements: Open and short circuited stubs (quarter wavelength, half wavelength)

Module:4	Microstrip Resonators	7 hours

Microwave resonators: Quarter & Half wave length resonators, Ring resonators: types, advantages and applications, Patch resonators.

Module:5	Microstrip Power Dividers	7 hours

Even and Odd mode analysis of equal &unequal Wilkinson Power Divider, Even & Odd mode analysis of branch line coupler and 180^{o} hybrid coupler, Coupled line coupler and its S-matrix, Ring coupler and its S-matrix.

Module:6	Bandpass Filter Design	6 hours

Band Pass Filter: Insertion loss method, Conversion from low pass to band pass, Design of band pass filter using lumped elements, distributed elements, impedance inverters, coupled lines.

Module:7	MIC & MMIC Fabrication Technologies	5 hours

Hybrid MICs, Configuration, Dielectric substances, thick and thin film technology, LTCC, HTCC, Printed Circuit Board technology (PCB), Fabrication process of MMIC.

Module:8	**Contemporary issues**	**2 hours**
	Total lecture hours:	**45 hours**

Text Book(s)	
1.	D. M. Pozar, Microwave engineering, 2012, 4th Edition, John Wiley, India.
2.	Leo G. Maloratsky, RF & Microwave Integrated Circuits: Passive components and control devices, 2012, 1st Edition, Elsevier Inc., India.
Reference Books	
1.	Ali A Behagi, RF and Microwave Circuit Design: Updated and Revised with 100 Keysight (Ads) Workspaces, 2017, 1st Edition, Techno Search, India.
2.	Jia Sheng Hong, M. J. Lancaster, Microstrip Filters for RF/Microwave Applications, 2012, 2nd Edition, Wiley-Blackwell, India.
3.	http://www.microwaves101.com/
Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)	

Recommended by Board of Studies	28-02-2016		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
ECE6019	Image Processing and Feature Extraction	3	0	2	0	4
Pre-requisite	Nil	Syllabus version				
		1.1				

Course Objectives:

1. To provide comprehensive understanding of digital image fundamentals.
2. To impart the principles of image enhancement and filtering techniques in spatial and frequency domain.
3. To introduce the core aspects of image segmentation and imbibe their utilization for real-time applications.
4. To provide knowledge on the feature extraction from images and classification

Course Outcomes:

1. Explore the basic elements of digital image processing.
2. Comprehend image sampling, DFT and apprehend the rational of image transforms.
3. Process the given images to enhance them in spatial and frequency domains.
4. Evaluate the theoretical and practical aspects of segmentation for dealing with computerized analysis.
5. Extract image features, identify and classify them.
6. Analyze the data usability for compaction aiding representation and description.
7. Comprehend the range of methods available for compression.

Module:1	Introduction to Image Processing	6 hours

Fundamental steps in DIP – Image Sampling and Quantization - Basic relationship between pixels. Image Transform: Two dimensional Fourier Transform- Discrete cosine transform – Multi-resolution analysis – Haar Transform- Discrete Wavelet Transform.

Module:2	Image Enhancement	8 hours

Spatial Domain: Basic Gray level Transformations – Histogram Processing – Smoothing spatial filters- Sharpening spatial filters.
Frequency Domain: Smoothing frequency domain filters- Sharpening frequency domain filters- Homomorphic filtering.

Module:3	Image Segmentation	8 hours

Image segmentation Techniques- Points, Edge and Corner detector - Region based approach- Clustering- Morphological techniques

Module:4	Feature extraction Techniques	8 hours

Geometry Features - Moment based features - Boundary and Region descriptors, Texture descriptor - Hough transform – Canny edge detector - Principal Components.

Module:5	Object Detection and Recognition	5 hours

Approaches to Object Recognition- Template matching - Neural network approach to Object Recognition- Structural methods.

Module:6	Image and Video Compression techniques	4 hours

Lossy and lossless Techniques – JPEG – JPEG2000 – MPEG-1, MPEG-2,MPEG-4 AVC/ITU-T H.264 standards

Module:7	**Video processing**	**4 hours**
Back ground subtraction – Motion detection – Motion estimation - Video segmentation		
Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing, 2013, 3rd Edition, Pearson Education, New Delhi, India.
2.	Anil. K. Jain, Fundamentals of Digital Image Processing, 2012, 7th Edition, Prentice Hall, Delhi, India.
3.	Mark Nixon, Alberto Aguado, Feature Extraction & Image processing, 2012, 2nd Edition, Elsevier academic Press, Oxford, UK.
4.	Al Bovik, Handbook of Image and Video processing, 2013, 2nd edition, Elsevier Academic Press, Burlington, USA.
Reference Books	
1.	William K. Pratt, Digital Image Processing, 2014, 2nd Edition, John Wiley & Sons, New Jersey, USA.
2.	Richard Szeliski, Computer vision: Algorithm and Applications, 2013, 1st Edition, Springer-Verlog, London, UK.
3.	A. Murat Tekalp, Digital Video Processing, 2015, 2nd Edition, Prentice Hall, New Delhi, India.
4.	Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, Digital Image Processing using MATLAB, 2014, 2nd Edition, Pearson Education, New Delhi, India.
5.	www.iprg.co.in

Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)

List of Challenging Experiments (Indicative)		
1.	Basic array operations on image	1 hours
2.	Interpolation and Decimation by factor of 2 of given image	1 hours
3.	Gray level and Bitplane slicing	2 hours
4.	Contrast stretching – Thresholding	2 hours
5.	Basic Gray level transformations	2 hours
6.	Perform histogram equalization for the given image	2 hours
7.	Spatial Domain Filtering (a) Low Pass Filtering (b) Order Statistics Filtering (c) High Pass Filtering	4 hours
8.	Transform domain (a) Obtain Fourier Spectrum using DFT (b) Obtain Discrete Cosine Transform and its Spectrum	4 hours
9.	Frequency Domain Filtering (a) Low Pass Filtering (b) High Pass Filtering	3 hours
10.	Image segmentation based on color and texture feature	2 hours
11.	Morphological Operations	3 hours
12.	Perform feature extraction studies and compression using frequency domain Technique	2 hours
13.	Perform feature extraction studies and compression using wavelet	2 hours

	domain Technique		
		Total laboratory hours	**30 hours**
Mode of evaluation: Continuous Assessment & Final Assessment Test (FAT).			
Recommended by Board of Studies	28-02-2016		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
ECE6020	Multirate Systems	2	0	0	4	3
Pre-requisite	Nil	Syllabus version				
		1.0				

Course Objectives:

1. To introduce the concepts of multirate signal processing.
2. To demonstrate the applications of multirate signal processing for communication systems.
3. To introduce the fundamental framework of wavelets in multirate signal processing perspective.
4. To acquaint the recent trends and technologies in multirate systems.

Course Outcome:

1. Design decimator and interpolator in both time and frequency domain.
2. Design multirate filter banks with subsequent error analysis
3. Design Perfect Reconstruction (PR) filters employing analysis and synthesis scheme
4. Design and realize linear-phase PR Finite Impulse Response Filters using lattice structures
5. Design and implement cosine modulated PR systems
6. Analyze and synthesize different wavelet basis in Time-frequency space
7. To design and realize systems using the imbibed multirate signal processing concepts

Module:1	Fundamentals of Multirate Systems	4 hours

Basic multirate operations, interconnection of building blocks, poly-phase representation, multistage implementation

Module:2	Multirate Filter Banks	6 hours

Maximally decimated filter banks: Errors created in the QMF bank, alias-free QMF system, power symmetric QMF banks. Poly-phase representation, Perfect reconstruction systems, alias-free filter banks

Module:3	Para-unitary Perfect Reconstruction Filter Banks	4 hours

Lossless transfer matrices, filter bank properties induced by paraunitary, two channel Para-unitary lattices, M-channel FIR Para-unitary QMF banks.

Module:4	Linear Phase Perfect Reconstruction QMF Banks	3 hours

Necessary conditions, lattice structures for linear phase FIR PR QMF banks, formal synthesis of linear phase FIR PR QMF lattice.

Module:5	Cosine Modulated Filter Banks	3 hours

Pseudo-QMF bank and its design, efficient poly-phase structures, properties of cosine matrices, cosine modulated perfect reconstruction systems.

Module:6	Wavelet Transform	4 hours

Short-time Fourier transform, Wavelet transform, discrete-time Orthonormal wavelets, continuous-time Orthonormal wavelets.

Module:7	Applications of multi-rate systems.	4 hours

Sub band coding, Trans-multiplexer, Conventional Digital Down Converters. Aliasing Digital Down Converters. Timing Recovery in a Digital Demodulator. Modem Carrier Recovery. Digitally Controlled Sampled Data Delay. Recursive All-pass Filter Delay Lines. Sigma-delta Decimating

Filter. FM Receiver and Demodulator.		
Module:8	**Contemporary issues**	**2 hours**
	Total lecture hours:	**30 hours**

Text Book(s)

1.	P. P. Vaidyanathan, Multirate Systems and Filter Banks, 2012, 1st Edition, Pearson Education, New Delhi, India.

Reference Books

1.	Fredric J Harris, Multirate Signal Processing for Communication Systems, 2012, 1st Edition, Pearson Education, New Delhi, India.
2.	Gilbert Strang, Truong Nguyen, Wavelets and Filter Banks, 2012, 1st Edition, Wellesley-Cambridge Press, Wellesley, USA.
3.	N. J. Fliege, Multirate Digital Signal Processing, 2012, 1st Edition, John Wiley & Sons, New Jersey, USA.
4.	https://www.ece.umd.edu/class/enee630.F2012/slides/part-1_sec1_2_handoutPreLec.pdf

Mode of Evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)

Typical Projects:

1. Adaptive speed control of speech without changing the pitch.
2. Filter design using optimization approach.
3. Sub band coding of speech.
4. Speech compression using discrete wavelet transform.
5. Medical signal analysis using filter bank
6. Design and analysis of Trans-multiplexer.
7. DCT analysis and synthesis system.
8. LPC analysis and synthesis of speech.
9. Study of Curvelets
10. Multirate systems for software defined radio.
11. Design and implementation of cascade integrator comb filter
12. Design of optimized DSP systems for audio processing using multirate filters and oversampling.
13. Extrapolation Techniques.
14. Broadband multirate systems for wireless multi user communication.
15. Computer aided design of linear phase QMF filter bank.

Mode of evaluation: Review I, II and III.

Recommended by Board of Studies	13-12-2015		
Approved by Academic Council	No. 40	Date	18-03-2016

Course Code	Course Title	L	T	P	J	C
ECE6021	Adaptive Signal Processing	2	0	0	4	3
Pre-requisite	Nil	Syllabus version				
		1.0				

Course Objectives:

1. To introduce stochastic processes and models in LTI systems.
2. To understand the LMS algorithm for iteratively estimating the Wiener filter weights.
3. To familiarize prediction filter formulation and applications
4. To derive the Lattice filter architecture from the Levinson-Durbin algorithm.

Course Outcomes:

1. Derive the response of LTI system to stochastic processes.
2. Comprehend and derive the Wiener filter for signals with known properties.
3. Familiar with the Lattice filter implementation of the prediction filter.
4. Analyze the convergence Properties of steepest descent.
5. Apply LMS algorithm to the lattice structure to improve convergence times.
6. Use Recursive Least Squares algorithms in signal processing.
7. Convergent with Unsupervised Adaptive filters applications.

Module:1	Adaptive Systems and Signal Analysis	4 hours

Signal Processing in unknown environments: System identification and Linear prediction-Stochastic Processes-Responses of LTI system to stochastic processes

Module:2	The Mean Square Error (MSE) Performance Criteria	4 hours

Introduction to Mean Square Error (MSE) and MSE Surface-Properties of the MSE Surface: The Normal Equations- Geometrical Properties of the Error Surfaces - Wiener filter.

Module:3	Linear Prediction and the Lattice Structure	4 hours

Levinson Durbin's Algorithm - Lattice Derivation-Forward and backward prediction-Adaptive lattice structures.

Module:4	The Method of Steepest Descent	4 hours

Iterative Solution of the Normal Equations- Weight Vector Solutions –Convergence Properties of Steepest Descent - Mean Square Error Propagation

Module:5	The Least Mean Squares (LMS) Algorithm	4 hours

Effects of Unknown Signal Statistics- Derivation of the LMS Algorithm- Convergence of the LMS Algorithm - LMS Mean Square Error Propagation-Normalized LMS Algorithm

Module:6	Recursive Least Squares Signal Processing	4 hours

Recursive Least squares (RLS) Adaptive Algorithms-Performance of RLS Adaptive Algorithms-Convergence of RLS versus LMS-QR RLS Algorithm.

Module:7	Unsupervised Adaptive filters	4 hours

Blind Equalizers –Sato Algorithm –Godard algorithms

Module:8	Contemporary Issues	2 hours

	Total lecture hours:		**30 hours**
Text Book(s)			
1.	Bernard Widrow, Samuel D. Stearns, Adaptive signal processing, 2012, 1st Edition, Pearson Education, New Delhi, India.		
2.	Simon Haykin, Adaptive Filter Theory, 2012, 4th Edition, Pearson Education, New Delhi, India.		
Reference Books			
1.	John R. Treichler, C. Richard Johnson, Michael G. Larimore, Theory and Design of Adaptive filters, 2012, 1st Edition, John Wiley & Sons, New Jersey, USA.		
2.	Behrouz Farhang, Boroujeny, Adaptive filters: Theory and Applications, 2013, 2nd Edition, John Wiley & Sons, New Jersey, USA.		
3.	Dimitris G. Manolakis, Vinay K. Ingle, Stephen M. Kogon, Statistical and Adaptive Signal processing, 2014, 1st Edition, The McGraw Hill Education, New Delhi, India.		
4.	http://www.cs.tut.fi/~tabus/course/ASP/Lectures_ASP.html		
Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)			
Typical Projects:			
1. Active noise control using adaptive filters 2. Adaptive cancellation of power line interference 3. Adaptive I/Q mismatch compensation. 4. Adaptive histogram equalization 5. Target tracking using Kalman filtering 6. Adaptive DPCM 7. Blind acoustic source separation using Nonlinear Adaptive Techniques 8. Adaptive channel equalization 9. Emperical mode decomposition. 10. Adaptive speaker Tracking. 11. Fetus heart beat detection. 12. Blind channel equalization. 13. Adaptive Interacting Multiple Model Technique. 14. Integration of wavelet with adaptive filtering. 15. Adaptive system for physical modeling of musical signals.			
Mode of evaluation: Review I, II and III.			
Recommended by Board of Studies	13-12-2015		
Approved by Academic Council	No. 40	Date	18-03-2016

Course Code	Course Title	L	T	P	J	C
ECE6022	Optical Broadband Access Networks	2	0	0	4	3
Pre-requisite	Nil	Syllabus version				
		1.0				

Course Objectives:

1. To provide a deep insight on enabling technologies for access networks.
2. To understand broadband access networks.
3. To familiarize the concept of network topology and access techniques.
4. To introduce long reach optical access and metro networks and WiMAX.

Course Outcomes:

1. Understand various enabling technologies for broadband access networks.
2. Analyze various multiple access schemes for broadband wireless technology.
3. Know various optical network topologies.
4. Understand various enabling broad band wireless technologies.
5. Understand the concepts of long reach and metro optical network.
6. Understand wireless access networks and Wi-MAX.
7. Deploy and test real-time implementation of optical broadband access networks.

Module:1	Introduction and Enabling Technologies	4 hours

The anatomy of an access network, the evaluation path typical access networks, broad band copper access network using ADSL2,VDSL2 Technology, fiber to the home/building (FTTH/B) access network, point to point Ethernet FTTH, passive optical network (PON) FTTH, wavelength division multiplexing (WDM) PON FTTH, hybrid fiber coax running DOCSIS protocol, wireless access network

Module:2	Enabling Techniques For Broad Band Access Networks	3 hours

Fiber in the access network: Fiber-DSL, hybrid fiber –coax, fiber –wireless, fiber to the home. basic optical access network components: Optical fiber, optical power splitter, wavelength routing devices

Module:3	Network Topology & Access Techniques	4 hours

FTTH network topologies: Point to point, point to multipoint, cost aspects. Multiple access techniques for a PON: Time division multiple access, subcarrier multiple access, optical code division multiple access, wavelength division multiple access. Radio over fiber, free space optical communication

Module:4	Enabling Broadband Wireless Technologies	5 hours

Modulation: Use of limited power, phase shift keying modulation, quadrature amplitude modulation, orthogonal frequency division multiplexing (OFDM). Coding techniques: Block Codes, convolution codes, turbo coding (TC), space time coding, coded modulation techniques. Adaptive modulation and coding (AMC). Multiple access techniques: Frequency division multiple access, time division multiple access, orthogonal frequency division multiple access, Combination of OFDM and CDMA system, carrier sense multiple access protocol.

Module:5	Long Reach Optical Access Networks	4 hours

Research challenges: Signal power compensation, optical source, burst mode receiver, upstream resource allocation. Demonstration of LR, PON-PLANET super PON, dynamic bandwidth assignment.

Module:6	**Optical Access and Metro Networks**	**3 hours**
Introduction, optical regional access network, Stanford university access network, metro access ring integrated network, OBS access metro networks. STARGATE- architecture, discovery and registration, dynamic bandwidth allocation and application.		
Module:7	**Optical –Wireless Access Networks and WiMAX**	**5 hours**
RoF: Introduction, basic technologies, RoF application areas, networking concepts and techniques. Integration of EPON and WiMAX: Introduction, integrated architecture for EPON and WiMAX, design and operation issues. Introduction to WiMAX, point to point, multipoint WiMAX networks, WiMAX mesh mode, mobility in WiMAX networks		
Module:8	**Contemporary Issues**	**2 hours**
	Total lecture hours:	**30 hours**

Text Book(s)

1.	Abdallah Shami, Martin Maeir, Chadi Assi, Broadband Access Network Technologies and Deployment (Optical Networks), 2014, 1st Edition, Springer, India.

Reference Books

1.	Leonid G. Kasovsky, Ning Cheng, Wei-tao Shaw, Shingwa Wong, Broad Band OpticalAccess Networks, 2012, 1st Edition, Wiley-Blackwell, India.
2.	Ivan Kaminov, Tingye Li, Alan E. Wilner, Optical Fiber Telecommunications VI B Systems and Networks, 2013, 6th Edition, Academic Press, India.
3.	http://www.cisco.com/c/en/us/solutions/collateral/service-provider/service-provider strategy/white_paper_c11-690395.html

Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)

Typical Projects:

1. Pre-emptive multi-wavelength scheduling in hybrid WDM/TDM passive optical networks
2. Interleaved polling versus multi-thread polling for bandwidth allocation in long-reach PONs
3. Wavelength hopping passive optical network (WH-PON) for provision of enhanced physical security
4. Scalable Passive Optical Network Architecture for Reliable Service Delivery
5. RPR-EPON-WiMAX hybrid network: A solution for access and metro networks
6. Interleaved polling versus multi-thread polling for bandwidth allocation in long-reach PONs
7. OCDMA Network design
8. Reducing Energy consumption in Green PON
9. Resource Allocation in WDM PON
10. EPON authorize discovery process scheduling algorithm and Scheduling
11. Energy efficient DB Algorithms
12. Colourless PON Architectures
13. Hybrid WDM/TDM routing
14. Performance Evaluation Of Hybrid OFDM/CDMA For wireless network.
15. Implementation of Turbo encoder and decoder
16. Comparison of Cable Modem and DSL technologies
17. Performance evaluation of Wi MAX and Wi Fi Networks
18. Optical Time Division Multiplexing and De multiplexing Techniques
19. Design and performance evaluation of radio over fiber system incorporating different

modulation techniques 20. Dense wavelength division multiplexing 21. Free space optical communication through atmospheric turbulence channels			
Mode of evaluation: Review I, II and III.			
Recommended by Board of Studies	13-12-2015		
Approved by Academic Council	No. 40	Date	18-03-2016

Course Code	Course Title	L	T	P	J	C
ECE6023	RF MEMS	3	0	0	0	3
Pre-requisite	Nil	Syllabus version				
		1.0				

Course Objectives:

1. To have the essential knowledge of various planar microstrip circuits.
2. To design and analyze various types of RF MEMS filters and resonator.
3. To acquaint the design of MEMS based circuits.

Course Outcome:

1. Comprehend the importance of micro machines and various transducers.
2. Understand the fabrication techniques for MEMS circuits.
3. Discern the principles of various MEMS devices.
4. Design and analyze RF MEMS resonators.
5. Design and analyze RF MEMS filters.
6. Understand the MEMS based circuits.

Module:1	Evolution of Microsystems	2 hours

Benefits of micro systems, concept of micro machines/ micro systems, Scaling laws, nanomachines.

Module:2	Introduction to Sensors, Actuators and Mathematical Models	2 hours

Various domains and classification of transducers: electrostatic, piezoelectric, thermal sensing principles: electrostatic, resistive, chemical etc. SAW devices.

Module:3	Surface Bulk Micro Machining	5 hours

Overview of silicon processes techniques, micro machining techniques and special processes for MEMS, polymer MEMS, recent advances in MEMS fabrication.

Module:4	RF MEMS Devices	11 hours

Enabled circuit elements and models – RF/Microwave substrate properties, Micro machined – enhanced elements – capacitors, inductors, varactors, MEM switch – shunt MEM switch, low voltage hinged MEM switch approaches, push-pull series switch, folded –beam – springs suspension series switch, MEMS modeling – mechanical modeling, electromagnetic modeling.

Module:5	MEMS Resonators	4 hours

Transmission line planar resonators, cavity resonators, micromechanical resonators, film bulk acoustics wave resonators.

Module:6	RF MEMS filters and Oscillators	9 hours

A Ka-Band millimeter-wave Micro machined tunable filter, A High-Q 8 MHz MEM Resonators filter, RF MEMS Oscillators – fundamentals, A14GHz MEM Oscillator, A Ka-Band Micro machined cavity oscillator.

Module:7	RF MEMS Based Circuit Design	10 hours

Phase shifters – fundamentals, X-Band RF MEMS phase shifter for phased array applications, Ka-Band RF MEMS phase shifter for radar systems applications, Film bulk acoustic wave filters – FBAR filter fundamentals, FBAR filter for PCS application

Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Hector J. De Los Santos, RF MEMS Circuit Design for Wireless Communications, 2012, 1st Edition, Artech House, India.
2.	Stepan Lucyszyn, Advanced RF MEMS(The Cambridge RF and Microwave Engineering Series, 2012, 1st Edition, Cambridge University Press, India.
Reference Books	
1.	Vijay K. Varadan, K. J. Vinoy, K.A. Jose, RF MEMS and their Applications, 2012, 1st Edition, John Wiley and sons, India.
2.	Gabriel M. Rebeiz, RF MEMS Theory, Design & Technology, 2013, 1st Edition, Wiley Interscience, India.
3.	http://ocw.mit.edu/index.htm
Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)	

Recommended by Board of Studies	13-12-2015		
Approved by Academic Council	No. 40	Date	18-03-2016

Course code	Course title	L	T	P	J	C
ECE6091	Foundations of Machine Learning	3	0	0	0	3

Pre-requisite	MAT 5006 - Mathematics for Communication Engineers	Syllabus version
		1.0

Course Objectives:

1. To get acquainted with data processing
2. To understand the importance and significance of Machine Learning
3. To understand the diverse learning methods
4. To preface the essentials of deep learning

Expected Course Outcomes:

1. To identify data discrepancies and eliminate noise, anomalies
2. To comprehend different steps involved in Machine Learning
3. To recognize the characteristics of ANN
4. To comprehend different types of learning
5. To implement different deep learning algorithms
6. To realize the impact of optimization in deep learning

Module:1	**Data Preprocessing**	**4 hours**

Basics of Vectors & Matrices – Overview: Data cleaning, Integration, Transformation & Reduction

Module:2	**Machine learning Essentials**	**9 hours**

Introduction, ML steps, data analysis for ML, generalization, regularization – L1, L2, applications

Module:3	**Introduction to Artificial Neural Networks**	**6 hours**

Models of neuron –Topology – characteristics of artificial neural networks – types of activation functions, ANN Architecture- Multilayer Perceptron – Back Propagation learning algorithm

Module:4	**Learning Methods**	**8 hours**

XOR Problem - Types of Learning – Supervised - Hebbian – Perceptron – Adaline, Unsupervised – Competitive learning NN, Kohonen SOM

Module:5	**Machine Learning Algorithms**	**6 hours**

Feature Selection - Normalization - Dimensionality reduction, Classifiers: KNN, SVM, Decision trees, Naïve Bayes - Clustering.

Module:6	**Introduction to Deep Learning**	**6 hours**

Convolution operation – Pooling – Efficient convolution algorithms- Reinforcement Learning

Module:7	**ML Framework - Toolbox**	**4 hours**

MATLAB-Python – Implementation-Computer Vision – Speech Recognition – Natural Language Processing applications

Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Reference Books	
1.	Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong, Mathematics for Machine Learning. Cambridge University Press 2020
2.	Ethem Alpaydin, "Introduction to Machine Learning", MIT Press, Prentice Hall of India, Third Edition 2014
3.	Simon Haykin, Neural Networks and Learning Machines, 2016, 3rd edition, Pearson Education Inc. India
4.	Kevin P Murphy. Machine Learning – A Probabilistic Perspective (Adaptive Computation and Machine Learning series). MIT Press 2012.
5	Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. Deep learning. MIT press, 2016.
6	Deep Learning: A Practitioner's Approach (English, Paperback, Josh Patterson, Adam Gibson)

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	14-09-2020		
Approved by Academic Council	No. 59	Date	24.9.2020

Course Code	Course Title	L	T	P	J	C
CSE6051	Information And Network Security	3	0	0	0	3
Pre-requisite	Nil	Syllabus version				
		1.1				

Course Objectives:

1. To familiarize the basic concepts in security mechanism, classical and traditional Encryption techniques.
2. To teach the significance of public key mechanism, message authentication and digital signature in cryptography.
3. To acquaint the different types of network security and its significance.

Course Outcomes:

1. Comprehend and analyze OSI Security Architecture and Symmetric Key Encryption.
2. Comprehend the various mathematic techniques in cryptography including number theory, Finite Field, modulo operator and Discrete Logarithm.
3. Analyze block ciphers, Data Encryption Standard (DES), Advanced Encryption Standard (AES) and public key cryptography.
4. Analyze Diffie-Hellman key exchange, ElGamal Cryptosystem in asymmetric key cryptosystem and authentication schemes.
5. Understand the different types of network security protocols and its standards.
6. Know the various network security mechanisms.

Module:1	Introduction	6 hours

Need of Security – OSI Security architecture – Security attacks – Security mechanisms – Model for network security – Information security management lifecycle –Classical Techniques - Substitution – Transposition

Module:2	Mathematics of Cryptography	8 hours

Number Theory, Finite Fields, Fermat's and Euler's Theorems - Euler's Totient function - The Chinese Remainder Theorem, Discrete Logarithms, Elliptic and Hyper elliptic curve Arithmetic.

Module:3	Secret Key Cryptography	8 hours

Block ciphers and Data Encryption Standard (DES): Double DES – Triple DES. Advanced Encryption Standard (AES) – IDEA.

Module:4	Public Key Cryptography	8 hours

Principles of Public Key Cryptography - RSA – Elliptic Curve Cryptography (ECC) – Digital Signatures - Key Management: Diffie-Hellman key exchange - Elgammal cryptosystem - Kerberos. Hash Functions: SHA and MD5 - Message Authentication Codes: HMAC.

Module:5	Network Security Protocols and Standards	5 hours

Application level security: PGP, S/MIME, HTTPS and SET. Security in transport layer: SSL and TLS. Security in Network Layer: IPsec, Internet Key Exchange (IKE) and VPN.

Module:6	Network Periphery Security	4 hours

Fire walls – Scanning, filtering and blocking – Virus filtering – Content filtering – Spam - Wireless LAN: WEP and Honeypots.

Module:7	**Cyber Crimes, Hackers and Forensics**	**4 hours**
Cyber Crimes and Laws – Hackers – Dealing with the rise tide of Cyber Crimes – Forensics analysis.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	William Stallings, Cryptography and Network security: Principles and Practice, 2014, 5th Edition, Pearson Education, Noida, India.
2.	Joseph Migga Kizza, Computer Network Security, 2012, 1st Edition, Springer Science & Business Media, New York, USA.
Reference Books	
1.	Christof Paar, Jan Pelzl, Understanding Cryptography – A Textbook for Students and Practitioners, 2014, 1st Edition, Springer Science & Business Media, New York, USA.
2.	Behrouz A. Forouzan, Debdeep Mukhopadhyay, Cryptography & Network Security, 2013, 3rd Edition, The McGraw Hill Education, New Delhi, India.
3.	Charlie Kaufman, Radia Perlman, Mike Speciner, Network Security: Private Communication in a public World, 2016, 2nd Edition, Pearson Education, Noida, India.
4.	http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-857-network-and-computer-security-spring-2014/

Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)

Recommended by Board of Studies	13-12-2015		
Approved by Academic Council	No. 40	Date	18-03-2016