CURRICULUM & SYLLABI
B.Tech. ELECTRONICS AND COMMUNICATION ENGINEERING

Effective from AY: 2024-25

NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL
WARANGAL, TELANGANA

Table of Contents

Vision and Mission of the Institute
National Institute of Technology Warangal

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product-oriented research for establishing a self-sustaining and wealth creating center to serve the societal needs.

Vision and Mission of the Department
ELECTRONICS AND COMMUNICATION ENGINEERING

VISION

Create an educational environment to mould the students to meet the challenges of modern Electronics and Communication industries through state-of-the-art technical knowledge and innovative experimental approaches.

MISSION

- To create learning, development and testing environment to meet ever challenging needs of the electronics and communication industries.
- To establish entrepreneurial environment and industry interaction for mutual benefit.
- To become a global training hub for generating human resources in the fields of chip design, communications and embedded systems.
- To associate with internationally reputed Institutions for academic excellence and collaborative research.

Program: B.Tech. Electronics and Communication Engineering

Program Educational Objectives

PEO-1	Analyze, plan and apply the knowledge acquired in basic sciences and mathematics towards solving Electronics and Communication Engineering problems with technical, economic, environmental and social contexts.
PEO-2	Design, build and test analog & digital electronic systems for given specifications.
PEO-3	Architect modern communication systems for current and next generation technologies.
PEO-4	Work in a team using technical know-how, industry standard environment to achieve project objectives.
PEO-5	Communicate effectively, demonstrate leadership qualities and exhibit professional conduct in their career.
PEO-6	Engage in lifelong learning, career enhancement and adapt to changing professional and societal needs.

Program Articulation Matrix

PEO / Mission Statements	PEO-1	PEO-2	PEO-3	PEO-4	PEO-5	PEO-6
To create learning, development and testing environment to meet ever challenging needs of the electronics and communication industries	2	1	2	2	1	1
To establish entrepreneurial environment and industry interaction for mutual benefit.	2	1	1	1	1	2
To become a global training hub for generating human resources in the fields of chip design, communications and embedded systems.	1	3	3	2	1	1
To associate with internationally reputed Institutions for academic excellence and collaborative research.	1	2	1	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Program: B.Tech. Electronics and Communication Engineering

Program Outcomes

PO-1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and Electronics and Communication Engineering to the solution of complex engineering problems.
PO-2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
PO-3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
PO-5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations..
PO-6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice..
PO-7	**Environment and sustainability:**Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO-9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
PO-10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehended write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO-11	**Project management and finance:** Demonstrate knowledge and understanding of the engineeringandmanagementprinciplesandapplythesetoone'sownwork,asamember and leader in a team, to manage projects and in multidisciplinary environments.
PO-12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes

PSO-1	Analyze and design electronic circuits and communication systems to enhance the quality of human life.
PSO-2	Develop innovative and environment-conscious technologies for a sustainable ecosystem.

CURRICULUM
B.Tech. Electronics and Communication Engineering

1st Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1161	Linear Algebra, Calculus and Ordinary Differential Equations	3-0-0	3
2	PY1161	Engineering Physics	3-0-2	4
3	HS1161	English for Technical Communication	2-0-2	3
4	MA1163	Computer Programming	3-0-2	4
5	BT1161	Biology for Engineers	2-0-0	2
6	EC1101	Programming Languages Lab	0-1-2	2
7	IC1101	EAA-I (Games & Sports / Yoga Wellness)	0-0-0	0
			Total Credits	**18**

2nd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1162	Integral Calculus, Vector Calculus and Laplace Transforms	3-0-0	3
2	CY1161	Engineering Chemistry	3-0-2	4
3	EE1163	Network Analysis	3-0-0	3
4	CS1162	Data Structures and Practice	3-0-2	4
5	EC1102	Design Thinking	0-1-4	3
6	EC1104	Electronic Devices and Circuits	3-0-0	3
7	EC1106	Electronic Devices and Circuits Laboratory	0-1-2	2
8	IC1102	EAA–II (Games & Sports / Yoga & Wellness)	0-0-0	0
			Total Credits	**22**

3rd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1265	Complex Variables and Special Functions	3-0-0	3
2	EC1201	Electronic Circuits and Analysis	3-1-0	4
3	EC1203	Signals and Systems	3-0-2	4
4	EC1205	Digital Circuit Design	3-0-0	3
5	EC1207	Networks and Transmission Lines	3-0-0	3
6	EC1209	Electronic Circuits and Analysis Lab	0-1-2	2
7	EC1211	Digital Circuit Design Lab	0-1-2	2
			Total Credits	**21**

4th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MS1262	Business Essentials for Engineers	3-0-0	3
2	EC1202	Digital System Design	3-0-0	3
3	EC1204	Probability Theory and Stochastic Processes	3-0-2	4
4	EC1206	Electromagnetic Fields and Waves	3-0-0	3
5	EC1208	Linear IC Applications	3-0-0	3
6	EC1210	IC Applications Lab	0-1-2	2
7	EC1212	Digital System Design Lab	0-1-2	2
			Total Credits	**20**

5th Semester

Sl.No.	Code	Course Title	L-T-P	Credits
1	EC1301	Data Networks	3-0-2	4
2	EC1303	Analog Communications	3-0-0	3
3	EC1305	Digital Signal Processing	3-0-0	3
4	EC1307	Microcontrollers	3-0-0	3
5	EC13XX	Professional Elective – I	3-0-0	3
6	EC1381	Fractal Course – I	1-0-0	0.5
7	EC1309	Microcontrollers Lab	0-1-2	2
8	EC1311	Digital Signal Processing Lab	0-1-2	2
			Total Credits	**20.5**

6th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	EC1302	Antennas and Propagation	3-0-2	4
2	EC1304	Digital Communications	3-0-0	3
3	EC1306	Product Development	0-1-4	3
4	EC13XX	Professional Elective – II	3-0-0	3
5	EC13XX	Professional Elective – III	3-0-0	3
6	EC1382	Fractal Course – II	1-0-0	0.5
7	EC1308	Electronic Measurements and Instrumentation Lab	0-1-2	2
8	EC1310	Analog and Digital Communications Lab	0-1-2	2
			Total Credits	**20.5**

7th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	EC1401	Microwave and Lightwave Technologies	3-0-0	3
2	EC14XX	Professional Elective – IV	3-0-0	3
3	EC14XX	Professional Elective – V	3-0-0	3
4	XXXXXX	Open Elective – I	2-0-0	2
5	EC1403	Microwave and Lightwave Technologies Laboratory	0-1-2	2
6	EC1489	Seminar and Technical Writing	0-0-0	2
7	EC1495	Minor Project	0-0-0	2
8	EC1491	Short-Term Industrial/EPICS/Research Experience	0-0-0	2
		Total Credits		**19**

8th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	EC14XX	Professional Elective – VI	3-0-0	3
2	EC14XX	Professional Elective – VII	3-0-0	3
3	EC14XX	Professional Elective – VIII	3-0-0	3
4	EC1498	Major Project	0-0-0	6
		Total Credits		**15**

Professional Elective Courses:

Professional Elective – I		
S.No.	**Code**	**Course Title**
1	EC1321	CMOS VLSI Design
2	EC1323	Organic Electronics
3	EC1325	Electronic Instrumentation

Professional Elective – II		
S.No.	**Code**	**Course Title**
1	EC1322	Introduction to Artificial Intelligence and Machine Learning
2	EC1324	Embedded and Real Time Operating Systems
3	EC1326	Web Technologies
4	EC2322	Low Power VLSI

Professional Elective – III		
S.No.	**Code**	**Course Title**
1	EC1328	Internet of Things
2	EC1330	Cellular and Mobile Communications
3	EC2302	Verification and Testing
4	EE1262	Control System Engineering

Professional Elective – IV		
S.No.	**Code**	**Course Title**
1	EC1421	Digital Image Processing and Computer Vision
2	EC1423	Hardware and Software Co-design
3	EC1425	Satellite Communications
4	EC2423	Electronics System Packaging

Professional Elective – V		
S.No.	**Code**	**Course Title**
1	EC1427	Computer Architecture and Organization
2	EC1429	Cryptography and Network Security
3	EC2427	Introduction to ASIC Design
4	EC2429	RF Microelectronics

Professional Elective – VI		
S.No.	**Code**	**Course Title**
1	EC1422	Advanced Digital Signal Processing
2	EC1424	Wireless Communication-5G Use Cases
3	EC1426	Telecom Switching
4	EC1428	Speech Processing

Professional Elective – VII		
S.No.	**Code**	**Course Title**
1	EC1430	Optimization Techniques
2	EC1432	Radar Engineering
3	EC1434	Software Defined Radio
4	EC2428	CAD for IC Design

Professional Elective – VIII		
S.No.	**Code**	**Course Title**
1	EC1436	Cloud based Technologies
2	EC1438	Adhoc Networks
3	EC1440	Biomedical Instrumentation and Signal Processing
4	EC1442	IPR and Cyber Laws

Basic Science Courses

S.No.	Code	Course Title	L-T-P	Credits
1	PH1161	Applied Physics	3-0-2	4
2	CY1161	Engineering Chemistry	3-0-2	4
3	MA1161	Linear Algebra, Calculus and Ordinary Differential Equations	3-0-0	3
4	MA1162	Integral and Vector Calculus, Laplace and Fourier Transforms	3-0-0	3
5	MA1265	Complex Variables and Special Functions	3-0-0	3
		Total Credits		**17**

Engineering Science Courses

S.No.	Code	Course Title	L-T-P	Credits
1	BT1161	Biology for Engineers	2-0-0	2
2	EE1163	Network Analysis	3-0-0	3
3	CS1162	Data Structures and Practice	3-0-2	4
4	MA1163	Computer Programming	3-0-2	4
5	EC1101	Programming Languages Lab	0-1-2	2
6	EC1102	Design Thinking	0-1-4	3
		Total Credits		**18**

Humanities and Social Science Courses

S.No.	Code	Course Title	L-T-P	Credits
1	IC1101	EAA-1 (Games & Sports/ Yoga wellness)	0-0-0	0
2	HS1161	English for Technical Communication	2-0-2	3
3	IC1102	EAA-2 (Games & Sports/ Yoga wellness)	0-0-0	0
4	MS1262	Business Essentials for Engineers	3-0-0	3
		Total Credits		**6**

The Overall Credit Structure

Course Category	Credits
Basic Science	17
Engineering Science	18
Humanities and Social Sciences	6
Program Core	89
Professional Elective	24
Open Elective	2
Total Graded Credit Requirement	**156**

Minor: ECE

S.No	Code	Course Title	L-T-P	Credits	Sem
1	EC1M61	Digital Electronics	3-0-0	3	3
2	EC1M62	Principles of Communication Systems	3-0-0	3	4
3	EC1M63	Sensors and Instrumentation	3-0-0	3	5
4	EC1M64	Introduction to Internet of Things	3-0-0	3	6
5	EC1M65	Fundamentals of Image Processing	3-0-0	3	7
		Total Credits		**15**	

Honors-1: Embedded & Machine Learning Systems

S.No	Code	Course Title	L-T-P	Credits	Sem
1	EC16005	FPGA Based Systems Design	3-0-2	4	5
2	EC16002	GPU Architectures and Programming	3-0-0	3	6
3	EC16001	Embedded Hardware Platforms and Programming	3-0-0	3	7
4	EC16003	Machine Learning Algorithms and Applications	3-0-0	3	7
5	EC16004	Hardware Accelerators Design for Machine Learning models	3-0-0	3	8
		Total Credits		**16**	

Honors-2: VLSI System Design

S.No	Code	Course Title	L-T-P	Credits	Sem
1	EC26001	Device Modeling	3-0-0	3	5
2	EC26002	Physical Design Automation	3-0-0	3	6
3	EC26003	Analog IC Design	3-0-0	3	7
4	EC26005	Digital IC Design	3-0-0	3	7
5	EC26004	Mixed Signal Design	3-0-0	3	8
		Total Credits		**15**	

Honors-3: Advanced Communication Systems

S.No	Code	Course Title	L-T-P	Credits	Sem
1	EC36005	RF Engineering	3-0-2	4	5
2	EC36004	Wireless Networks	3-0-0	3	6
3	EC36001	Detection and Estimation Theory	3-0-0	3	7
4	EC36003	Advanced Digital Communications	3-0-0	3	7
5	EC36002	Advanced Wireless Communication	3-0-0	3	8
		Total Credits		**16**	

SYLLABI
B.Tech. Electronics and Communication Engineering

1st Semester

MA1161 **3-0-0 (3)**

Linear Algebra, Calculus and Ordinary Differential Equations

Pre-requisites: **None**

Course Outcomes:

CO-1	Understand to solve the consistent system of linear equations
CO-2	Apply orthogonal transformations to a quadratic form
CO-3	Determine the series expansion of a given function
CO-4	Explore the properties of functions of several variables
CO-5	Solve arbitrary order linear differential equations

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	1	2	1	–	–	–	–	–	–	–	1	1
CO-2	3	3	1	2	1	–	–	–	–	–	–	–	-	-
CO-3	3	3	1	2	1	–	–	–	–	–	–	–	1	-
CO-4	3	3	1	2	1	–	–	–	–	–	–	–	-	-
CO-5	3	3	1	2	1	–	–	–	–	–	–	–	2	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Linear Algebra: Vector space, Subspace, Examples, Linear span, Linear independence and dependence, Basis, Dimension, Extension of a basis of a subspace, Intersection and sum of two subspace, Examples. Linear transformation, Kernel and Range of a linear map, Rank-Nullity Theorem (without proof). Rank of a matrix, Row, and column spaces, Solvability of the system of linear equations, Inner product spaces, Orthogonal basis, Gram-Schmidt orthogonalization process. Eigenvalues, Eigenvectors, and properties Caley-Hamilton Theorem (without proof) and applications, diagonalization of a matrix, diagonalization by similarity, and orthogonal transformations.

Differential Calculus: Taylor's theorem with remainders; Taylor's and Maclaurin's expansions;Functions of several variables – continuity, differentiability, partial derivatives, Euler's theorem, change of variables, Jacobians, Functional dependence; Maxima andminima of functions of several variables (2 and 3 variables) - Lagrange's method of multipliers.

Ordinary Differential Equations: First order differential equations - Basic definitions, Geometric interpretation of solutions of first-order ODE $y' = f(x, y)$, Exact differential equations, Integrating factors, Linear equation, Reducible to linear form: Bernoulli's equations; Orthogonal trajectories; Higher order linear differential equations with constant coefficients - Cauchy-Euler and Legendre's differential equations, Method of variation of parameters - System of linear differential equations; Applications to physical problems.

Learning Resources:

Text Books:

1. Howard Anton and Chris Rorres, Elementary Linear Algebra with Supplementary Applications,

John Wiley & Sons, 2014, Eleventh Edition.
2. George B. Thomas and Ross L. Finney, Calculus and Analytic Geometry, Pearson, 2020, Ninth Edition.
3. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 2015, Eighth Edition.

Reference Books:

1. Dennis G. Zill, Advanced Engineering Mathematics, Jones & Bartlett Learning, 2018, Sixth Edition.
2. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 2016, Fifth Edition.

PY1161 **3-0-2 (4)**

Engineering Physics

Pre-Requisites: **None**

Course Outcomes:

CO-1	Examine the concepts of Interference, diffraction, polarisation to solve engineering problems
CO-2	Assess the technological applications of lasers and optical fibers
CO-3	Apply the quantum mechanical principles for solving engineering problems
CO-4	Understand the basics of nanomaterials and their engineering applications
CO-5	Demonstrate the production, detection and applications of ultrasonics

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	1	1	1	–	–	–	–	–	–	–	3	1
CO-2	3	3	1	1	1	–	–	–	–	–	–	–	3	1
CO-3	3	3	2	1	1	–	–	–	–	–	–	–	3	1
CO-4	3	3	2	1	1	–	–	–	–	–	–	–	3	1
CO-5	3	3	2	1	1	–	–	–	–	–	–	–	3	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Interference: Principle of Superposition, Coherence and Coherent Sources, Production of Coherent Light, Young's Double Slit Experiment, Concept of interference, Newton's Rings, working of Michelson Interferometer, Fabry-Perot Interferometer, and its application as wavelength filter.

Diffraction: Definition and types of Diffractions, Huygen's Principle and types of wave fronts, types of Diffraction, Single Slit Diffraction, Double Slit Diffraction, Diffraction Grating, Derivation of Resolving Power and Dispersive Power, Rayleigh's Criterion and applications.

Polarization: Introduction to Polarization, Production of Polarized Light by Reflection and Refraction, Phenomenon of Double Refraction, Construction and Working of Nicol's Prism, Half-Wave and Quarter Waveplates, Representation of Different Polarized Lights, Optical Activity, Practical Applications of Polarized Light, Construction and Working of Laurent's Half Shade Polarimeter and Engineering Applications.

Lasers & Optical Fibers: Basic theory of Laser, Fundamentals of lasers, Einstein Coefficients, Characteristics of Laser Pumping Mechanisms; Basic Components of Laser System, 2-Level, 3-Level and 4-Level Systems, Construction and working of He-Ne, Nd-YAG, and semiconductor diode Lasers and Engineering Applications of Lasers. Basic Principle of Optical Fiber, Derivation-Numerical Aperture and Acceptance Angle, Types of Optical Fibers (Step and Graded Index, Single Mode and Multimode), Applications in Communications and Sensors.

Quantum Mechanics: Concepts and experiments that led to the discovery of Quantum Nature, de Broglie hypothesis of matter waves, Heisenberg uncertainty principle, Schrodinger time independent and time dependent wave equations, the free particle problem, Particle in an infinite and finite potential well, Quantum mechanical tunnelling and applications.

Nanomaterials: Introduction and importance of Nanomaterials, classification (0D, 1D, 2D and 3D) of nanomaterials, properties of nanomaterials, carbon-based nanomaterials, synthesis of nanomaterials, top-down and bottom-up approaches, characterization of nanomaterials, Engineering Applications of Nanomaterials

Ultrasonics: Production, detection, and applications of ultrasonics

List of Experiments:

1. Determination of Wavelength of Sodium light using Newton's Rings.
2. Determination of Wavelength of He-Ne laser - Metal Scale.
3. Measurement of Width of a narrow slit using He- Ne Laser.
4. Determination of Specific rotation of Cane sugar by Laurent Half-shade Polarimeter.
5. Determination of Numerical aperture, loss, Acceptance angle of optical fiber.
6. Determination of plank constant by photo electric effect.
7. Determination of I – V characteristics of photo diode.
8. Diffraction grating by normal incidence method.
9. Determination of capacitance by using R-C circuit.
10. Determination of resonating frequency and bandwidth by LCR circuit
11. Strain Gauge
12. Dielectric constant measurements
13. Determination of carrier concentration, charge by using Hall effect experiment
14. Study of I-V characteristics of Solar Cell
15. Determination of velocity of ultrasonic waves and adiabatic compressibility of liquids using ultrasonic interferometer.

Learning Resources:

Text Book:

1. Fundamentals of Physics by Halliday, Resnic and Walker, John Wiley, 2011, Ninth Edition.
2. Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury, Concepts of Modern Physics , McGraw Hill Publications, 2009, Sixth edition.
3. Shatendra Sharma, Jyotnsa Sharma, Engineering Physics, Pearson Education,2018.
4. Nanotechnology: principles and practices by Sulabha K. Kulkarnl. Springer publications, 2018, 3 Ed.
5. Practical Physics by G.L. Squire, Cambridge University press, 2001, fourth edition.

Reference Books:

1. Ajoy K. Ghatak, Optics by Tata McGraw Hill, 2017, Sixth Edition.
2. Jeff Hecht, Understanding Lasers An Entry-Level Guide, Wiley Publications, 2018, Fourth edition.
3. M.N. Avadhanulu, P.G. Khirsagar, A Textbook of Engineering Physics 2011, 9th edition.
4. Hugh D. Young,Roger A. Freedman, University Physics with modern physics by Pearson Education,2014.
5. B. Rogers, J Adams and S. Pennathur, Nanotechnology the whole story, CRC Press, 2013.
6. Dr.S.K. Gupta, Engineering Physics Practical Krishna Prakashan Publications, 2010, ninth edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/122/107/122107035/

HS1161 **2-0-2:(3)**

English for Technical Communication

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand and apply principles of technical communication to interact effectively in diverse environments.
CO-2	Analyze complex technical documents to extract and synthesize key information.
CO-3	Employ reported speech, active and passive voice in engineering and scientific contexts to compile technical reports.
CO-4	Demonstrate use of English speech sounds, stress, and intonation in day-to-day situations, conversations, and interactions.
CO-5	Interpret technical data presented in the form of graphs, pie charts, and diagrams.
CO-6	Critique and provide constructive feedback on peer communication performances and written works.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	2	1	1	-	-	-	-	-	-	1	2	1
CO-2	3	3	2	1	1	-	-	-	-	-	-	1	2	1
CO-3	3	3	2	1	1	-	-	-	-	-	-	1	2	1
CO-4	3	3	2	1	1	-	-	-	-	-	-	1	2	1
CO-5	3	3	2	1	1	-	-	-	-	-	-	1	2	1
CO-6	3	3	2	1	1	-	-	-	-	-	-	1	2	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Grammar Principles & Effective Sentence Construction: Correction of Sentences and Concord, - Vocabulary Building, - Synonyms and Antonyms, - Idioms and Phrasal Verbs: Patterns of Use and Suggestions for Effective Employment in Varied Contexts, - Technical Vocabulary (Jargons and Registers),- Strategies for Bringing Variety and Clarity in Sentences, - Removing Ambiguity, - Editing Long Sentences for Brevity and Clarity, - Reported Speech, - Contexts for Use of Reported Speech, - Impact on Audiences and Readers, - Active and Passive Voice, - Reasons for Preference for Passive Voice in Scientific English

Writing- Paragraph & Letter: Definition of Paragraph and Types, - Features of a Good Paragraph, - Unity of Theme, - Coherence, - Linking Devices, - Direction, - Patterns of Development**.** - Importance in the Context of Other Channels of Communication, - Qualities of Effective Letters, - Types of Letters, - Official Letters, - Letters for Various Purposes, - Letters of Application for Jobs, - Cover Letter and Resume Types, - Letters for Internship/Fellowship, - Writing Statements of Purpose (SOPs), - Examples and Exercises

Reading Techniques: Definition and Importance, - Skills and Sub-Skills of Reading, - Skimming and Scanning: Uses and Purposes, Examples and Exercises, - Reading Comprehension, - Reading Silently and with Understanding, - Process of Comprehension, - Types of Comprehension Questions

Technical Writing: Principles of a Technical Report, - Know Your Audience, Purpose, and Length of Report, - Understand the Cornerstones of a Presentation, - Define Various Purposes of Presentations and Plan the Correct Structure, - Writing Clear Sentences and Paragraphs, - Removing Jargon, Redundancy, and Wordiness, - Kinds of Graphics and Their Messages, - Suitability for Placement in Graphic Representation, - Introduction to Basic Concepts in Research, - Abstract, Keywords, Methodology, Hypothesis, Plagiarism, Critical Reading, - Abstract Writing, - How to Read Scientific Articles, - Basics of Writing a Research Project Proposal, - Preparation and Presentation of Project Reports

Reviews: Oral and Written Review of a Chosen Novel/Play/Movie, - Review of Scientific Articles and Science Fiction, - Focus on Appropriate Vocabulary and Structure, - Use of Special Vocabulary and Idioms

Language laboratory

1. English Sound System -vowels, consonants, Diphthongs, phonetic symbols- using dictionary to decode phonetic transcription-- Received Pronunciation, its value and relevance- transcription.

2. Stress and Intonation –word and sentence stress - their role and importance in spoken English- Intonation in spoken English -definition, -use of intonation in daily life-exercises

3. Introducing oneself in formal and social contexts- Role plays. - their uses in developing fluency and communication in general.

4. **Oral presentation** - definition- occasions- structure- qualities of a good presentation with emphasis on body language and use of visual aids.
5. **Listening Comprehension**- Challenges in listening, good listening traits, some standard listening tests- practice and exercises.
6. **Debate/ Group Discussions**-concepts, types, Do's and don'ts- intensive practice, Guided writing practice with examples, drafting – the mindset to avoid writer's block, checking your own reports and presentations, Giving and receiving constructive feedback.

Learning Resources:

Text Books:

1. Humanities And Social Sciences Division, Anna University, Chennai, A Textbook Of English For Engineers and Technologists (Combined Edition), Orient Blackswan, 2010, First Edition
2. M Ashraf Rizvi, Effective Technical Communication, Tata McGraw-Hill, 2006, 2e

Reference Books:

1. Meenakshi Raman and Sangeetha Sharma,Technical Communication: Principles and Practice, Oxford University Press, 2011, 2nd Edition.
2. Tan, Zhongchao. Academic Writing for Engineering Publications: A Guide for Non-native English Speakers, Springer, 2022, 1st Edition

Other Suggested Readings:

Software:

1. Clear Pronunciation – Part-1 Learn to Speak English.
2. Clear Pronunciation – Part-2 Speak Clearly with Confidence
3. Study Skills
4. English Pronunciation

MA1163 **3-0-2: (4)**

Computer Programming

Pre-Requisites: **None**

Course Outcomes:

CO-1	Design algorithms for solving simple mathematical problems including computing, searching and sorting
CO-2	Compare and contrast algorithms in terms of space and time complexity to solve simple mathematical problems
CO-3	Explore the internals of computing systems to suitably develop efficient algorithms
CO-4	Examine the suitability of data types and structures to solve specific problems
CO-5	Apply control structures to develop modular programs to solve mathematical problems
CO-6	Apply object-oriented features in developing programs to solve real world problems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	3	3	2	2	-	-	2	-	-	1	-	-
CO-2	3	3	2	2	2	2	-	2	2	-	-	1	-	-
CO-3	3	3	2	2	2	-	-	2	2	-	-	1	-	-
CO-4	2	3	2	1	2	2	-	-	2	-	-	1	-	-
CO-5	2	3	2	2	2	2	-	-	2	-	-	1	-	-
CO-6	2	3	2	2	2	2	-	-	2	-	-	1	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Fundamentals of Computers: Historical perspective, Early computers, Components of a computers, Problems, Flowcharts, Memory, Variables, Values, Instructions, Programs.

Problem solving techniques: Algorithmic approach, characteristics of algorithm, Problem solving strategies: Top-down approach, Bottom-up approach, Time and space complexities of algorithms.

Number systems and data representation: Basics of C++, Basic data types, Numbers, Digit separation, Reverse order, writing in words, Development of Elementary School Arithmetic Testing System, Problems on Date and factorials, Solutions using flow of control constructs

Conditional statements: If-else, Switch-case constructs, Loops - while, do-while, for.

Functions: Modular approach for solving real time problems, user defined functions, library functions, parameter passing - call by value, call by reference, return values, Recursion,

Introduction to Pointers and Arrays: Sorting and searching algorithms, Large integer arithmetic, Single and Multi-Dimensional Arrays, passing arrays as parameters to functions, Magic square and matrix operations using Pointers and Dynamic Arrays, Multidimensional Dynamic Arrays String processing, File operations.

Structures and Classes: Declaration, member variables, member functions, access modifiers, function over loading, Problems on Complex numbers, Date, Time, Large Numbers.

PSCP LAB:

1. Programs on conditional control constructs.
2. Programs on loops (while, do-while, for).
3. Programs using user defined functions and library functions.
4. Programs on arrays, matrices (single and multi-dimensional arrays).
5. Programs using pointers (int pointers, char pointers).
6. Programs on structures.
7. Programs on classes and objects.

Learning Resources:

Text Books:

1. Walter Savitch, Problem Solving with C++, Pearson, 2014, tenth Edition.
2. Cay Horstmann, Big C++, Wiley, 2009, Second Edition.

Reference Books:

1. R.G. Dromey, How to Solve it by Computer, Pearson, 2008.

Other Suggested Readings:

1. https://nptel.ac.in/courses/106/105/106105151/
2. https://onlinecourses.nptel.ac.in/noc21_cs38/preview

BT1161 **2-0-0 (2)**

Biology for Engineers

Pre-Requisites: **None**

Course Outcomes:

CO-1	Realize the significance of biomolecules for sustaining life
CO-2	Identify the difference between unicellular to multi-cellular organisms
CO-3	Understand heredity, variation and central dogma of life
CO-4	Apply the concepts of biology for engineering the cell

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	2	2	–	–	2	2	–	–	2	–	3	3	3
CO-2	3	2	2	–	–	2	–	–	–	–	–	3	3	3
CO-3	3	2	2	–	–	2	–	–	–	–	–	3	3	3
CO-4	3	3	2	2	1	2	2	1	–	2	–	3	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Molecules of Life: Chemical basis of life, Proteins, Nucleic acids, Carbohydrates, Lipids, Membranes and First cell**,** Inside the cell**,** Cell cycle and Division.

Information processing in living system: Central dogma, Concept of Gene, Genetic code, Transcription, Translation, Biological signal transduction, Quorum sensing and Biofilm formation.

Biomolecular machines and motors: Cytoskeletal motor proteins, ATP synthase, Cell motility.

Applied Biotechnology: Biocomputing, Synthetic biology, Biosensors, Biomedical instrumentation in disease diagnosis, Biomimicry, Biomechanics, Biomaterials, Nanobiotechnology, Industrial and Environmental Biotechnology.

Learning Resources:

Text Books:

1. Quillin, Allison Scott Freeman, Kim Quillin and Lizabeth Allison, Biological Science, Pearson Education India, 2016

Reference Books:

1. Reinhard Renneberg, Viola Berkling and Vanya Loroch, Biotechnology for Beginners, Academic Press, 2017

EC1101 **0-1-2 (2)**

Programming Languages Lab

Pre-Requisites: **None**

Course Outcomes:

CO-1	Develop the application specific codes using python
CO-2	Understand Strings, Lists, Tuples and Dictionaries in Python
CO-3	Verify programs using modular approach, file I/O, Python standard library
CO-4	Implement Digital Systems using Python

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6		PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	2	1	–	2	–		–	–	2	–	–	2	1	1
CO-2	2	2	1	–	2	–		–	–	2	–	–	2	1	1
CO-3	2	2	1	–	2	–		–	–	2	–	1	2	1	1
CO-4	2	2	2	–	2	–		–	–	2	–	–	2	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Expressions, Data types, Variables, Flow Control concepts, While Loops, For Loops Functions: Built-in functions, Writing own functions, Global and local scopes, Error handling Lists, For loops with lists, multiple assignment and augmented operators, List methods Dictionary Datatype and Data structures, string syntax, string methods, String formatting

Regular expressions: Basics, Groups, Character classes, Repetition in Regex patterns, Regex method Files Reading and writing, copying and moving, deleting, Directory tree

Debugging: raise and assert statements, logging, debugger

Web scraping: Web browser, downloading with web requests, Parsing HTML Reading and editing of spreadsheets, PDFs and Word documents Numpy, Pandas, Data visualization libraries, Jupyter Notebook, Python IDEs

Exercise 1 Basics
Running instructions in Interactive interpreter and a Python Script.
Write a program to purposefully raise Indentation Error and correct it.
Exercise 2 Operations
Write a program to compute GCD of two numbers by taking input from the user.
Write a program add.py that takes 2 numbers as command line arguments and prints its sum.
Exercise - 3 Control Flow
Write a Program for checking whether the given number is even number or not.
Write a program using for loop that loops over a sequence.
Python Program to Print the Fibonacci sequence using while loop.

Python program to print all prime numbers in a given interval (use break).

Exercise – 4 Lists

Find mean, median, mode for the given set of numbers in a list. Write a program to convert a list and tuple into arrays.

Write a program to find common values between two arrays.

Exercise – 5 Dictionary

Write a program to count the numbers of characters in the string and store them in a dictionary data Structure.

Write a program combined lists into a dictionary.

Exercise – 6 Strings

Write a program to check whether a string starts with specified characters.

Write a program to check whether a string is palindrome or not.

Exercise -7 Strings Continued

Python program to split and join a string.

Python Program to Sort Words in Alphabetic Order.

Exercise -8 Files

Write a program to print each line of a file in reverse order.

Write a program to compute the number of characters, words and lines in a file.

Write a program to count frequency of characters in a given file.

Exercise - 9 Functions

Simple Calculator program by making use of functions.

Find the factorial of a number using recursion.

Write a function dups to find all duplicates in the list.

Write a function unique to find all the unique elements of a list.

Exercise - 10 Functions - Problem Solving

Write a function cumulative_ product to compute cumulative product of a list of numbers.

Write a function reverse to print the given list in the reverse order.

Write function to compute GCD, LCM of two numbers.

Exercise- 11 Multi-D Lists

Write a program that defines a matrix and prints.

Write a program to perform addition of two square matrices.

Write a program to perform multiplication of two square matrices

Exercise - 12 - Modules

Install NumPy package with pip and explore it.

Exercise - 13

Write a program to implement Digital Logic Gates – AND, OR, NOT, EX-OR.

Write a program to implement Half Adder, Full Adder, and Parallel Adder.

Learning Resources:

Reference Books:

1. Vamsi Kuruma, Python Programming: A Modern Approach, Pearson, 2018.
2. Mark Lutz, Learning Python, O' Reilly, 2013, 5th Edition.
3. A. B. Downey, Think Python, How to Think Like a Computer Scientist, O′Reilly, 2015.
4. Z. Shaw, LEARN PYTHON 3 THE HARD WAY, Addison-Wesley, 2017.

Other Suggested Readings:

1. Online training tutorials on Python with online compiler.
2. https://onlinecourses.nptel.ac.in/noc24_cs57/preview
3. https://onlinecourses.swayam2.ac.in/cec24_cs01/preview

2nd Semester

MA1162 **3-0-0 (3)**

Integral Calculus, Vector Calculus and Laplace Transforms

Pre-requisites: MA1161

Course Outcomes:

CO-1	Analyze improper integrals for extracting certain properties of beta and gamma integrals.
CO-2	Evaluate multiple integrals in different coordinate systems.
CO-3	Apply the concepts of gradient, divergence and curl of scalar and vector point functions to formulate engineering problems.
CO-4	Convert line integrals into area integrals and surface integrals into volume integrals.
CO-5	Apply Laplace transforms to solve physical problems arising in engineering.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	1	2	1	–	–	–	–	–	–	–	1	2
CO-2	3	3	1	2	1	–	–	–	–	–	–	–	1	2
CO-3	3	3	1	2	1	–	–	–	–	–	–	–	1	2
CO-4	3	3	1	2	1	–	–	–	–	–	–	–	1	2
CO-5	3	3	1	2	1	–	–	–	–	–	–	–	1	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Integral Calculus: Improper integrals; Beta and Gamma functions, and their properties; Differentiation under integral sign, Evaluation of double and triple integrals; Areas and Volumes, Change of order of integration; Change of variables in double and triple integrals.

Vector Calculus: Scalar and vector fields; Vector differentiation; Level surfaces; Directional derivative; Gradient of a scalar field; Divergence and curl of a vector field; Laplacian operator; Parametrization of curves and surfaces; Line, surface and volume integrals; Green's theorem in a plane; Stoke's theorem; Gauss divergence theorem.

Laplace Transforms: Laplace transforms; Inverse Laplace transforms; Properties of Laplace transforms; Laplace transforms of unit step, impulse and periodic functions; Convolution theorem; Applications of Laplace transforms - solving certain initial value problems - solving system of linear differential equations - finding responses of systems to various inputs viz. sinusoidal inputs acting over a time interval, rectangular waves, impulses.

Learning Resources:

Text Books:

1. George B. Thomas and Ross L. Finney, Calculus and Analytic Geometry, Pearson, 2020, Ninth Edition
2. Dennis G. Zill, Advanced Engineering Mathematics, Jones & Bartlett Learning, 2018, Sixth Edition

Reference Books:

1. Maurice D. Weir, Joel Hass and Christopher Heil, Thomas' Calculus: Early Transcendentals, Pearson, 2014, Thirteenth Edition.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 2015, Eighth Edition.
3. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 2016, Fifth Edition.

CY1161 **3-0-2 (4)**

Engineering Chemistry

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the basic concepts of chemistry relevant to materials.
CO-2	Apply electrochemical concepts for energy harvesting, conversion and storage.
CO-3	Analyze the properties of materials for various applications.
CO-4	Comprehend the concepts of instrumentation principles, Spectroscopy and procedures involved in characterization of materials
CO-5	To analyze the metal contents from the ores by understanding the redox process
CO-6	To determine the rate of corrosion by a redox reaction and understand the concept of adsorption

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	-	-	-	-	-	-	-	-	-	-	2	-	3
CO-2	3	-	-	-	-	-	-	-	-	-	2	2	1	3
CO-3	3	2	-	-	-	-	-	-	-	-	2	2	1	3
CO-4	3	-	-	-	-	-	-	-	-	-	2	2	1	3
CO-5	3	3	3	-	2	-	2	-	-	-	1	1	-	3
CO-6	3	3	3	-	2	2	-	-	-	1	1	-		3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Chemical Kinetics and Thermodynamics: Order of a Reaction, Theories of Reaction Rates. Homogeneous and Heterogeneous Catalysis. Thermodynamic variables, Laws of Thermodynamics, Thermodynamic Relationships and Applications.

Electrochemistry and Energy Systems: Introduction to Electrochemistry, Nernst's law and its applications. Batteries, fuel cell and photo-electrochemical systems. Corrosion and its prevention.

Transition Metal Chemistry and Organometallic Chemistry: Bonding in transition metal complexes; Crystal field and MO Theories, Jahn-Teller effect. Properties of Coordination complexes; Metal Carbonyls, EAN and 18-electron rule, Ligands and hapticity; Type of reactions: Oxidative addition, Reductive elimination, Migratory insertion, Hydrogenation, Hydro formylation, Monsanto process and Wacker process.

Engineering Materials: Inorganic and Organic Semiconductors, Magnetic materials, Liquid crystals, Superconductors, Photo conducting Materials and conducting polymers.

Chromatographic and Spectroscopic Methods: Liquid Chromatographic and Gas Chromatographic methods. UV-VIS, spectroscopy, Infrared spectroscopy, NMR spectroscopy.

List of Experiments:

1. Standardization $KMnO_4$ solution
2. Estimation of metal content in an ore
3. Estimation of Calcium in milk powder by complexometry
4. Extraction and identification of DNA from green peas/onions
5. Estimation of iodine in iodized common salt
6. Blue printing of an object by photochemical reaction
7. Kinetics of acid hydrolysis of methyl acetate
8. Determination of acid strength in citrus fruit
9. Verification of Beer-Lambert Law and estimation of concentration of food color
10. Evaluation of E^o values of $Zn|Zn^{2+}$ and $Cu|Cu^{2+}$ Electrodes and measure the emf by constructing the Daniel cell
11. Estimation of phosphoric acid in soft drinks by pH metry
12. Separation of natural pigments from mixture using paper chromatography
13. Determination of efficiency of a corrosion inhibitor
14. Verification of Freundlich adsorption isotherm
15. Preparation of a polymer and its analysis
16. Estimation of active pharmaceutical ingredient in a drug

Learning Resources:

Text Books:

1. Shashi Chawla, A Text Book of Engineering Chemistry, Danpathrao & Co. Publications, 2007, 6th India reprint edition
2. Ashutosh Kar, Text Book of Engineering Chemistry, ED-Tech Publications, 2018
3. William Kemp, Organic Spectroscopy, Macmillan Education, Limited, 2017
4. Introductory Chemistry laboratory manual: Concepts and Critical Thinking, Charles Corwin, Pearson Education, 2012.
5. Investigating Chemistry: Laboratory Manual, David Collins, Freeman & Co., 2006.

Reference Books:

1. Michael F. Ashb, David R.H. Jones, Engineering Materials, Elsevier Science, 2012
2. V. Raghava, Material Science and Engineering, PHI Learning, 2015
3. J.M. Martin, Materials for Engineering, Elsevier Science, 20006
4. Peter Atkins, Julio de Paula, James Keeler, Physical Chemistry, Oxford University Press, 2018.

EE1163 **3-0-0 (3)**

Network Analysis

Pre-Requisites: **None**

Course Outcomes:

CO-1	Simplify DC networks and analyze them using loop and node equations and determine the dual of a given network
CO-2	Analyze magnetic circuits, and electric circuits with sinusoidal excitation along with the phenomenon of resonance
CO-3	Formulate the dynamic equations of electric circuits using differential equations and simplify their solutions using Laplace.
CO-4	Simplify the analysis of electric circuits using network theorems and Two port Networks.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	3	3	3	2	1	1	1	1	1	3	--	--
CO-2	3	3	3	3	3	2	1	1	1	1	1	3	--	--
CO-3	3	3	3	3	3	2	1	1	1	1	1	3	--	--
CO-4	3	3	3	3	3	2	1	1	1	1	1	3	--	--

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Circuit Elements and Relations: Types of circuit components, Types of Sources and Source Transformations, Star-delta transformation, KVL and KCL with dependent and independent Sources, DC circuit analysis, Formation of loop and node equations. Graph of a network- incidence matrix, Dual networks.

Magnetic Circuits: Concept of MMF, flux and magnetic reluctance, self and mutual inductances, Dot convention, coefficient of coupling and coupled circuits.

Steady-state Analysis of Circuits for Sinusoidal Excitations: Concept of phasor, Single phase Series, Parallel, Series Parallel circuits, Concept of power factor, Solution of AC networks using mesh and nodal analysis, Phasor diagrams. Resonance, Series and Parallel resonance, Bandwidth, Q-factor and selectivity.

Time Domain Analysis: Solution of network equations in time domain, Classical differential- equations approach, Initial conditions & evaluation, applications to simple RLC circuits only.

Applications of Laplace Transforms in Circuit Theory: Laplace transforms of various signals of excitation, Laplace transformed networks.

Network Theorems: Superposition theorem, Thévenin's theorem, Norton's theorem, Maximum power transfer theorem, Millman's theorem, Tellegen's theorem.

Two-port parameters: Relationship of two port variables, Short circuit admittance parameters, open circuit impedance parameters, Transmission parameters, Hybrid parameters, Interrelationships, parallel connections of two port networks.

Learning Resources:

Text Books:

1. M. E. VanValken Burg, Network Analysis, PHI, 2015, 3 Edition.
2. William H. Hayt, Jack Kemmerly, Steven M. Durbin, Engineering Circuit Analysis, Tata McGraw-Hill, 2013, 8th Edition.

Reference Books:

1. M. L. Soni and J.C. Gupta, A Course in Electrical Circuit Analysis, Dhanpat Rai & Co. (P), 2001.
2. G.K Mittal & Ravi Mittal, Network Analysis, Khanna Publications, 2003, 14th Edition.
3. Gopal G Bhise, Prem R Chadha &Durgesh C. Kulshreshtha Gopal, Engineering Network Analysis and Filter Design, Umesh Publications, 2012.
4. S.R. Paranjothi, Electric Circuit Analysis, New Age International Pub.,2002.
5. De Carlo & Lin, Linear circuit Analysis, Oxford University Press, 2010, 2nd Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/104/108104139/
2. https://nptel.ac.in/courses/108/102/108102097/

CS1162 **3–0–2 (4)**

Data Structures and Practice

Prerequisites: **MA1163**

Course Outcomes:

CO-1	Understand the basic techniques of algorithm analysis and assess how the choice of data structures impact the performance of programs.
CO-2	Solve problems using data structures such as linear lists, stacks, queues, hash tables, binary trees, heaps, binary search trees, AVL trees and writing programs for these solutions.
CO-3	Implement graphs as adjacency matrix, adjacency list, Searching technique - Breadth First Search and Depth First Search.
CO-4	Analyze, evaluate and choose appropriate data structures and algorithms for a specific application.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	2	2	2	-	-	-	-	2	-	-	1	1	1
CO-2	3	2	2	2	-	-	-	-	2	-	-	2	2	2
CO-3	2	2	2	2	-	-	-	-	2	-	-	1	2	2
CO-4	3	2	2	2	-	-	-	-	2	-	-	2	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Data Structures, Asymptotic Notations, Theorems and Examples based on Asymptotic Notations, Stack Data Structure and its Applications, Queue Data Structure and its Applications, Linked Lists, Trees and tree traversals, Dynamic Sets and Operations on Dynamic Sets, Binary Search Tree and its Operations, Heap Data Structure

Priority Queue, AVL Trees., Direct Addressing; Introduction to Hashing, Collision Resolution by Chaining, Collision Resolution by Open Addressing, Lower Bound for Comparison based Sorting Algorithms, Insertion Sort, Merge Sort, Quick Sort.

Heap Sort and Counting Sort, Radix Sort, Introduction to Graphs and Representation of Graphs, Depth First Search (DFS), Breadth First Search (BFS), Applications: BFS and DFS.

Algorithms: Prim's Algorithm for finding Minimum Spanning Tree (MST), Kruskal's Algorithm for finding MST, Dijkstra's Algorithm for Single Source Shortest Paths

Floydd-Warshall Algorithm for All-Pairs Shortest Path Problem

Laboratory Experiments:

1. Write a program to implement stack using arrays.
2. Write a program to evaluate a given postfix expression using stacks.
3. Write a program to convert a given infix expression to postfix form using stacks.
4. Write a program to implement circular queue using arrays.
5. Write a program to implement double ended queue (de queue) using arrays.
6. Write a program to implement a stack using two queues such that the *push* operation runs in constant time and the *pop* operation runs in linear time.
7. Write a program to implement a stack using two queues such that the *push* operation runs in linear time and the *pop* operation runs in constant time.
8. Write a program to implement a queue using two stacks such that the *enqueue* operation runs in constant time and the *dequeue operation* runs in linear time.
9. Write a program to implement a queue using two stacks such that the *enqueue* operation runs in linear time and the *dequeue* operation runs in constant time.
10. Write programs to implement the following data structures:
    (a) Single linked list
    (b) Double linked list
11. Write a program to implement a stack using a linked list such that the *push* and *pop* operations
12. Write a program to implement a queue using a linked list such that the *enqueue* and *dequeue* operations
13. Write a program to create a binary search tree (BST) by considering the keys in given order and perform the following operations on it.
    (a) Minimum key
    (b) Maximum key
    (c) Search for a given key
    (d) Find predecessor of anode
    (e) Find successor of anode
    (f) delete a node with given key
14. Write a program to construct an AVL tree for the given set of keys. Also write function for deleting a key from the given AVL tree.
15. Write a program to implement hashing with (a) Separate Chaining and (b) Open addressing methods.

Learning Resources:

Text Books:

1. Thomas H. Cormen, Charles E Leiserson, Ronald L. Rivest and Clifford Stein, Introduction to Algorithms, PHI, 2009, 2nd Edition.
2. Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, Pearson Education, 2006, Third Edition.

Reference Books:

1. Ellis Horowitz, Sartaj Sahni and Sanguthevar Rajasekaran, Fundamentals of Computer Algorithms, Universities Press, 2011, 2nd Edition.
2. Michael T.Goodrich and Roberto Tamassia, Algorithm Design: Foundations, Analysis and Internet Examples, Wiley India, 2006, 2nd Edition.

Other suggested Readings:

1. https://nptel.ac.in/courses/106/106/106106130/
2. https://nptel.ac.in/courses/106/106/106106145/
3. https://nptel.ac.in/courses/106/102/106102064/

EC1102 **0-1-4 (3)**

Design Thinking

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify design principles from an engineering perspective
CO-2	Cultivate sensitivity towards design aspects of Activities, Environments, Interactions, Objects, and Users (A-E-I-O-U) in daily life
CO-3	Validate problem statements through user empathization with societal and environmental consciousness
CO-4	Devise visual design and documentation to communicate more effectively
CO-5	Develop project management skills in a multidisciplinary environment

Course Articulation Matrix

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	1	1	2	2	1	3	-	-	-	-	-	-	-	-
CO-2	1	1	1	2	2	1	2	1		1	1	1	2	1
CO-3	2	2	3	3	1	2	3	1	1	1	1	1	1	3
CO-4	2	2	2	2	1	2	-	-	2	3	2	1	-	1
CO-5	2	1	1	-	-	1	-	-	-	-	3	1	-	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

MODULE-1: Design Overview and Motivation
Design is Everywhere – Various perspectives including history; Design Vocabulary; Design in Indian Context; Art and Design; Importance of Design in Career

MODULE-2: Understanding Design

Design Engineering vs. Engineering Design; Good and Bad Design — Case Studies, Introduction to the Design Double Diamond: Discover-Define-Develop-Deliver; Importance of user-centricity for design

MODULE-3: Doing Design: Discover Phase

Looking for problems: SDGs; Identifying Stakeholders and Defining User Personas; User Empathisation and Tools; Data collection from users and for users: Surveys, Questionnaires, Statistics, Interactions
Need Analysis: Types of Users, Types of Needs; Market Size; Value Proposition to the Users; Identifying Addressable Needs and Touchpoints; Data Validation; Structuring, Need Statements.

MODULE-4: Designing Customer Service Experience

Enhancing Customer Experience in Services through Innovation and Design Thinking; Service Development Process and Case Studies; Service Experience Cycle and Case Studies

MODULE-5: Communication Skills for Design

Communicating using various media to express an idea in print, electronic, mobile, web, and social media: Visuals, Text, Voice and Audio, Infographics
General Guidelines for a Good Presentation: Target Audience, Slideshow Templates, Appropriate Visual Elements and Aesthetics, Typography, Presentation Styles,
General Guidelines for a Good Report: Documentation Classification, Standards, Styles, and Templates

MODULE-6: Sustainable Design Approaches

Concern for Environment and Sustainability in Design, Case Studies to understand good Design For Environment (DFE) Decisions; Design Considerations in the five stages of the Product Life Cycle

STUDENTS' RESPONSIBILITIES:

1. Forming diverse teams of 3–5 members each to work collaboratively throughout the semester.

2. Proactively engaging to observe the objects and interactions in their daily life and society from a design perspective.

3. Identifying general societal and social problems that may be effectively addressed using design thinking principles

4. Presenting and reporting the tasks to the concerned faculty members using their creative communication and people skills.

ACTIVITIES:

1. Introduction and briefing (15 minutes)

2. Ice-breaker activity (20 minutes)

3. Introduction to Design Thinking (20 minutes)

4. Building empathy for the user (1 hour)

5. Define a problem statement (1 hour)

6. Ideation part 1: Generate ideas and potential solutions (1 hour)

    Presentation (5 minutes): What is ideation?

    Activity—worst possible idea (10 minutes)

    Activity—coming up with solutions (10 minutes)

    Activity—sharing ideas and getting feedback (10 minutes)

    Activity—refining your solution (10 minutes)

    Reflection and discussion (5 minutes)

7. Ideation part 2: User journey mapping (1 hour)

    Presentation (10 minutes): What is a user journey map?

Activity—define the activities and steps in the customer's experience (15 minutes)

Activity—group the steps into phases (10 minutes)

Activity—adding goals and pain-points (15 minutes)

Sharing user journey maps, reflection and discussion (10 minutes)

8. Prototype and test ideas (1 hour)

Presentation (5 minutes):

Activity—create mobile screens (15 minutes)

Activity—add functionality to mobile screens (15 minutes)

Activity—user testing (15 minutes)

Activity—decide on a winning approach (10 minutes):

9. Debrief and outline next steps (15 minutes)

Exercises:

1) The Pin-Up Exercise

2) The Systems Thinking Exercise

3) The 48-Hour Crash Course Exercise

4) The Design with Empathy Exercise

5) The Tinker Toy Exercise

6) The Wallet Exercise

7) The Pitch Competition Exercise

8) "Yes, but" vs. "Yes, and" exercise

9) "Five whys" or "Nine Whys" exercise

10) The "Six Thinking Hats" exercise

Learning Resources:

Text Books:

1. Tim Brown, "Change by Design", Harper Business, 2012 (ISBN: 978-0062337382)
2. Donald A. Norman, "The Design of Everyday Things", MIT Press, 2013 (ISBN: 978-0262525671)
3. Daniel Ling, "Complete Design Thinking Guide for Successful Professionals", Create Space Independent Publishing, 2015 (ISBN: 978-1514202739)
4. Andrew Pressman, Design Thinking: A guide to creative problem solving for everyone Routledge Taylor and Francis group, 2019, 1st edition.
5. George E. Dieter, Linda C. Schmidt , Engineering Design, McGraw-Hill Education, 2019, 5th edition.
6. Ulrich, K., Eppinger, Product design and development, S. and Yang, M., 2020, 7th edition.

Reference Books:

1. Bruno Munari, “Design as Art”, Penguin UK, 2009 (ISBN: 978-0141035819)
2. Tom Kelly, Jonathan Littman, “The Art of Innovation”, HarperCollins Business, 2002 (ISBN: 978-0007102938)
3. Thomas Lockwood, “Design Thinking: Integrating Innovation, Customer Experience, and Brand Value”, Allworth Press, 2009 (ISBN: 978-1581156683)
4. Joost Groot Kromelink, “Responsible Innovation: Ethics, Safety and Technology”,2nd ed., TU Delft, Faculty of Technology, Policy and Management, 2019 (e-Book ISBN: 978-9463662024)
5. Jimmy Jain, “Design Thinking for Startups: A Handbook for Readers and Workbook for Practitioners”, Notion Press, 2018 (ISBN: 978-1642495034)

Other Suggested Readings:

1. https://www.arvindguptatoys.com/
2. https://honeybee.org/
3. https://dschool.stanford.edu/resources/getting-started-with-design-thinking
4. https://designthinking.ideo.com/

EC1104 **3–0–0 (3)**

Electronic Devices and Circuits

Pre-Requisites: **PY1161**

Course Outcomes:

CO-1	Understand the working of diode and transistors
CO-2	Characterize the basic circuits using diodes, transistors and FETs
CO-3	Analyze the characteristics of various diodes, transistors, FETs and rectifiers
CO-4	Understand the importance of biasing of transistors

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	1	3	-	2	-	-	-	1	1	1	2	2	1
CO-2	2	2	3	2	2	-	-	-	1	1	1	2	2	1
CO-3	2	2	3	2	3	-	-	-	1	1	1	2	2	1
CO-4	2	2	3	-	2	-	-	-	1	1	1	2	2	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Semiconductor Diodes: Intrinsic and extrinsic semiconductors, transport of carriers, mobility and resistivity, drift and diffusion currents. the band-structure of p-n junction, p-n junction in equilibrium, depletion region, built-in potential, p-n junction under reverse bias, junction capacitance, p-n junction under forward bias, I-V characteristics, reverse breakdown: Zener and avalanche breakdown. Ideal diode, p-n junction as a diode, temperature effects and breakdown voltages, Transition and diffusion capacitance of p-n junction diodes, diode models.

Applications of diode: Half wave, full wave, bridge rectifiers, Capacitor, Inductor, L-section and π-section filters. Zener diode as voltage regulator. Clipping and clamping circuits.

Special Diodes: Tunnel Diode, Gunn diode, and Schottky diode.

Bipolar Junction Transistors: PNP and NPN transistors, Characteristics of the current flow across the base regions, Minority and majority carrier profiles, Transistor as a device in CB, CE and CC configurations, and their characteristics.

Biasing and Thermal Stability: The operating Point, DC and AC load lines, Fixed Bias, Collector Feedback Bias, Emitter Feed Back Bias, Voltage divider Bias, Stabilization, stabilization circuits, Thermal runaway, and thermal stability.

Field-Effect Transistors: JFET and its characteristics, Pinch off voltage and drain saturation current.

MOSFET: The MOS capacitor, n-channel enhancement-mode MOSFET: transistor structure, I-V characteristics, PMOS, MOSFET dc circuit analysis, basic MOSFET applications: switch, digital logic gate and amplifier. Biasing of FETs and MOSFETs.

Learning Resources:

Text Books:

1. Jacob Millman, Christos C Halkias, and Satyabrata Jit, Electronic Devices and Circuits, McGraw Hill, 2016, 4th Edition.
2. Donald Neamen, Microelectronics Circuit Analysis and Design, McGraw Hill, 2010, 4th Edition.

Reference Books:

1. Robert L Boylestad and Louis Nashelsky, Electronic Devices and Circuit Theory, Pearson, 2018, 11th Edition.
2. Adel S Sedra, K C Smith and A N Chandorkar, Microelectronic Circuits: Theory and Applications, Oxford University Press, 2017, 7th Edition.
3. Richard C Jaeger and Travis N Blalock, Microelectronic Circuit Design, McGraw Hill, 2016, 5th Edition.
4. Ben G. Streetman, S K Banerjee, Solid State Electronic Devices, Pearson, 2015, 7th Edition.
5. David A Bell, Electronic Devices and Circuits, Oxford University Press, 2008, 5th Edition.

Other suggested Readings:

1. https://nptel.ac.in/courses/117/105/117105147/
2. https://nptel.ac.in/courses/117/108/117108038/
3. https://onlinecourses.nptel.ac.in/noc21_ee86/preview

EC1106 **0–1–2 (2)**

Electronic Devices and Circuits Laboratory

Pre-Requisites: **EC1104**

Course Outcomes:

CO-1	Plot the characteristics of semiconductor diodes and transistors to understand their behavior.
CO-2	Design, construct and test amplifier circuits and interpret the results.
CO-3	Operate electronic test equipment and hardware/software tools to characterize the behavior of devices and circuits.
CO-4	Design and test the diode clippers, clampers and rectifiers.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	3	2	-	1	-	-	-	2	-	-	2	1	1
CO-2	1	3	2	2	1	-	-	-	2	-	-	2	1	1
CO-3	1	3	2	2	1	-	-	-	2	-	-	2	1	1
CO-4	1	3	2	2	1	-	-	-	2	-	-	2	1	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

List of Experiments:

1. Study of Instruments and components
2. Soldering Practice
3. V-I Characteristics of Si and Ge Diodes
4. Zener Diode Characteristics and Zener Diode as Voltage Regulator
5. Clippers and clampers
6. Half Wave and Full Wave Rectifiers
7. BJT Characteristics
8. FET Characteristics
9. BJT Biasing
10. FET Biasing
11. BJT as an Amplifier
12. Mini project

Except experiments 1 and 2, all experiments must be simulated on Pspice/Modelsim software and compare with hardware experiment results.

Learning Resources:

Text Books:

1. Jacob Millman, Christos C Halkias, and Satyabrata jit, Electronic Devices and Circuits, McGraw Hil, 2016, l4th Edition.
2. Donald Neamen, Microelectronics Circuit Analysis and Design, McGraw Hill, 2010,4th Edition.
3. Robert L Boylestad and Louis Nashelsky, Electronic Devices and Circuit Theory, Pearson, 2017, 11th Edition.
4. Ben Streetman, Solid State Electronic Devices, Pearson, 2015, 7th Edition
5. Richard C Jaeger and Travis N Blalock, Microelectronic Circuit Design, McGraw Hill, 2016, 5th Edition.
6. David A Bell, Electronic Devices and Circuits, Oxford publication, 2008, 5th Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/117/105/117105147/
2. https://nptel.ac.in/courses/117/108/117108038/
3. https://onlinecourses.nptel.ac.in/noc21_ee86/preview

3rd Semester

MA1265 **3-0-0 (3)**

Complex Variables and Special Functions

Prerequisites: **None**

Course Outcomes:

CO-1	Evaluate contour integrals of functions of complex variables
CO-2	Examine improper integrals using complex variables
CO-3	Determine the series solutions of Legendre and Bessel equations
CO-4	Assess series solution of ordinary differential equations at a singular point
CO-5	Construct a function for data using cubic splines

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	1	-	-	-	-	-	-	-	-	-	-	-	-
CO-2	3	1	-	-	-	-	-	-	-	-	-	-	-	-
CO-3	3	1	-	-	-	-	-	-	-	-	-	-	-	-
CO-4	3	1	-	-	-	-	-	-	-	-	-	-	-	-
CO-5	3	1	-	-	-	-	-	-	-	-	-	-	-	-

Syllabus:

Review of complex numbers, nth roots of complex number, Regions in the complex plane, Functions of a complex variable, Limit and continuity, Functions of a complex variable, Limit and continuity, Derivative, CR-equations, analytic functions, Contour integrals, anti-derivatives, Contour integrals, anti-derivatives, Cauchy-Goursat Theorem, Cauchy Integral Formula.

Taylor‘s and Laurent‘s series expansions, Zeros and singularities, Residues, Residue theorem, Evaluation of improper integrals, Mapping by Elementary functions, Linear fractional transformations (Bilinear transformation), conformal mapping, Schwartz Christoffel transformation. Ordinary points, Classification of singular points of an ordinary differential equation Series solutions

Power series method, Legendre equation, Legendre polynomials and their orthogonal property, Generating function, Regular Singular Points, Method of Frobenius.

Bessel equation, Bessel function of first kind, Generating function, orthogonal property of Bessel functions, Sturm-Liouvelle Problems, Splines and cubic spline functions, Properties and applications, Piecewise approximation with M‘s and m‘s

Learning Resources:

Text Books:

1. R.V. Churchill, Complex variables and its applications, McGraw Hill, 2017, 8th Edition
2. S.S. Sastry, Introductory methods of Numerical Analysis, PHI, 2012, 5th Edition.
3. W.W. Bell, Special Functions For Scientists and Engineers, Dover Publications, 2004.
4. Erwin Kreyszig: Advanced Engineering Mathematics, John Wiley and Sons, 2010, 10th Edition.

5. B.S. Grewal: Higher Engineering Mathematics, Khanna Publications, 2014, 43th Edition.

Reference Books:

1. Advanced Engineering Mathematics: by C. R. Wylie & L. C. Barrett, McGraw Hill, 6th Edition
2. Advanced Engineering Mathematics: by R. K. Jain & S. R. K Iyengar, Narosa Pub. House, 2019, 6th Edition.
3. Complex variables and Applications: by R. V. Churchill, T. J. Brown & R. F. Verhey, McGraw Hill, 2013, 9 th Edition.

EC1201 **3-1-0 (4)**

Electronic Circuits and Analysis

Pre-Requisites: **EC1104**

Course Outcomes:

CO-1	Learn the fundamentals of various amplifiers
CO-2	Understand the high-frequency models of BJT and FETs
CO-3	Develop analytical capability to analyze the feedback in amplifiers
CO-4	Determine the key parameters responsible for the performance of amplifiers and oscillators

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	1	3		2	-	-	-	-	-	1	2	2	1
CO-2	2	2	3	2	2	2	-	-	-	-	1	2	2	1
CO-3	2	2	3	2	3	-	-	-	-	-	1	2	2	1
CO-4	2	2	3		2	-	-	-	-	-	1	2	2	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Low-Frequency Transistor Amplifier Circuits: Small-signal equivalent circuit of the transistors (BJT & MOSFET) using re model and 'h'-parameters, Analysis of single stage BJT amplifier circuits (CE, CB & CC), Analysis of single stage MOSFET amplifier circuits (CS, CG & CD), Low frequency response of amplifier circuits, Effect of bypass and coupling capacitors on the low frequency response of the amplifier.

High-Frequency Response Transistor Amplifier Circuits: Classification of amplifiers, Distortion in amplifiers, Frequency response of an Amplifier, Bode plots, Step response of an amplifier, CE short circuit current gain, Internal capacitance effect, High frequency model of the MOSFET and BJT, High frequency response of CS and CE amplifiers. Miller's theorem, High frequency response of source and emitter follower, Gain bandwidth product. Cascode stage: cascode as a current source, cascode as an amplifier.

Differential and Multistage Amplifiers (BJT case): differential pair, common mode and differential mode operation. Small and large signal operation, CMRR, current mirror load. Analysis of Multistage amplifier, Design of two stage amplifier, Frequency response of cascaded stages.

Feedback Amplifiers: Classification and representation of amplifiers, Feedback concept, and transfer gain with feedback, General Characteristics of negative feedback amplifiers. Impedance in feedback amplifiers. Properties of feedback amplifier topologies, approx. analysis of feedback amplifiers, Method

of analysis of a feedback amplifier. The shunt feedback triple, Shunt-series pair, Series shunt pair, series triple, general analysis of multistage feedback amplifiers.

Oscillators: Sinusoidal oscillators, Barkhausen Criterion, Analysis and design of RC phase shift (BJT) oscillator, Wien bridge oscillators. Resonant circuit oscillators, General form of oscillator circuit (Hartley &Colpitts), Crystal oscillators

Learning Resources:

Text Books:

1. Robert L Boylestad and Louis Nashelsky, Electronic Devices and Circuit Theory, Pearson, 2013, 11th Edition.
2. Donald Neamen, Microelectronics Circuit Analysis and Design, McGraw Hill, 2010, 4th Edition.

Reference Books:

1. Richard C Jaeger and Travis N Blalock, Microelectronic Circuit Design, McGraw Hill, 2016, 5th Edition.
2. Adel S Sedra, K C Smith and A N Chandorkar, Microelectronic Circuits: Theory and Applications, Oxford University Press, 2017, 7thEdition.
3. Ben Streetman, Solid State Electronic Devices, Pearson, 2015, 7th Edition.
4. Jacob Millman, Christos Halkias, Chetan Parikh, Integrated Electronics (Analog & Digital Circuits & Systems), McGraw Hill Education, 2017, 2nd Edition.
5. David A Bell, Electronic Devices and Circuits, Oxford publication, 2008, Fifth edition,

Other suggested Readings:

1. https://nptel.ac.in/courses/117/105/117105147/
2. https://nptel.ac.in/courses/117/108/117108038/
3. https://onlinecourses.nptel.ac.in/noc21_ee86/preview
4. Analog Electronic Circuits by Prof. S.C. Dutta Roy (IITD).
5. Introduction to Electronic Circuits by Prof. S.C. Dutta Roy (IITD).
6. Analog Circuits by Prof. A.N. Chandorkar (IITB)

EC1203 **3-0-2 (4)**

Signals and Systems

Pre-Requisites: **None**

Course Outcomes:

CO-1	Classify the signals as Continuous time and Discrete time
CO-2	Analyze the spectral characteristics of signals using Fourier analysis.
CO-3	Classify systems based on their properties and determine the response of LTI system using convolution.
CO-4	Understand the process of sampling to convert an analog signal into discrete signaland Apply Z- transform of continuous-time and discrete-time signals for stability analysis.
CO-5	Demonstrate the principles of signals & systems through simulation.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	1	1	1	1	-	-	-	-	-	-	1	2	1
CO-2	3	1	1	1	1	2	-	-	-	-	-	1	2	1
CO-3	3	1	1	1	2	-	-	-	-	-	-	1	2	1
CO-4	2	3	1	1	1	-	-	-	-	-	-	1	2	1
CO-5	2	3	1	1	2	3	-	-	-	-	-	1	2	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

SIGNALS AND SYSTEMS: Continuous Time and Discrete Time signals, Exponential and Sinusoidal Signals, Unit Impulse and Unit Step Functions, Continuous and Discrete Time Systems, basic System Properties.

LINEAR TIME INVARIANT SYSTEMS: Discrete Time LTI Systems, Continuous Time LTI Systems, properties of LTI Systems, causal LTI Systems Described by Difference equations.

FOURIER SERIES REPRESENTATION OF PERIODIC SIGNALS:

Response of LTI systems to Complex Exponentials, Fourier series Representation of CT periodic Signals, properties of CT Fourier Series, Fourier Series representation of DT periodic Signals, properties of DFS, Fourier series and LTI Systems, Filtering, Examples of CT filters, Examples of DT filters.

CONTINUOUS TIME FOURIER TRANSFORM: Representation of a periodic Signals by continuous FT, FT of periodic signals, convolution and multiplication property of continuous FT, systems characterized by Linear Constant Coefficient Differential Equations.

TIME AND FREQUENCY CHARACTERIZATION OF SIGNALS AND SYSTEMS: Magnitude and phase representation of FT, Magnitude and phase response of LTI systems, Time domain and Frequency domain aspects of ideal and non-ideal filters.

DISCRETE TIME FOURIER TRANSFORM (DTFT) and DISCRETE FOURIER TRANSFORM (DFT): Properties of DTFT and DFT, convolution property, multiplication property, Duality, Systems characterized by Linear Constant Coefficient Difference Equations.

SAMPLING: Sampling theorem, Proof of Sampling theorem, Effect of under sampling-aliasing, Types of sampling Techniques, Data reconstruction-ideal reconstruction filter, zero order Hold.

Z-TRANSFORMS: Z-transforms, Region of convergence and its properties, Inverse Z transform, properties of ZT, Analysis and characterization of LTI systems using ZT.

Lab Experiments:

1. Introduction to MATLAB
2. Generation of continuous time signals.
3. Basic operations on the signals.
4. Transformation of signals into time and frequency domains.
5. Convolution between signals and sequences
6. Write a MATLAB program to Calculate and plot Fourier Transform and Z-Transform of a given signal.
7. Write a MATLAB program to Verify Sampling theorem.

Learning Resources:

Text Books:**:**

1. AV Oppenheim, AS Willsky, S Hamid Nawab, Signals and Systems, PHI, 2000, 2nd edition,
2. Robert A. Gable, Richard A. Roberts, Signals and Linear Systems, John Wiley, 1995, 3rd edition.
3. John G. Proakis, Dimitris G. Manolakis, Digital Signal Processing, Principles, Algorithms, and Applications, PHI, 2007 4th Edition.

Reference Books:

1. Simon Haykin, Barry Van Veen Signals and Systems, Wiley, 2018, 2nd edition.

Other suggested Readings:

1. https://archive.nptel.ac.in/courses/108/104/108104100/

EC1205 **3-0-0 (3)**

Digital Circuit Design

Pre-Requisites: **None**

Course Outcomes:

CO-1	Design of combinational and sequential logic circuits and develop Verilog models
CO-2	Understand characteristics of the TTL/CMOS logic families and realize Boolean equation using CMOS logic
CO-3	Understand fault detection techniques for digital logic circuits
CO-4	Understand SRAM/DRAM organization and periphery circuitry, operation of SRAM cell, DRAM cell, DDR2/DDR4 and SD card

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	3	2	-	2	-	-	-	-	-	-	1	2	1
CO-2	2	3	-	-	2	-	-	-	-	-	-	1	2	1
CO-3	-	2	-	-	2	-	-	-	-	-	-	1	2	1
CO-4	2	2	1	-	2	-	-	-	2	-	-	1	2	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Number Systems and Codes: Representation of unsigned and signed integers, Floating Point representation of real numbers, Laws of Boolean Algebra, Theorems of Boolean Algebra, Realization of functions using logic gates, Canonical forms of Boolean Functions, Minimization of Functions using Karnaugh Maps.

Combinational circuit design: Design with basic logic gates, comparators, data selectors, priority encoders, decoders, full adder, serial binary adder, parallel binary adders-ripple-carry adder, carry-look ahead adder; Parallel prefix adders- Carry select Adder, Conditional sum adder, Kogge-stone Adder, Brent-kung adder, Verilog models.

Sequential circuit design: Memory elements and their excitation functions SR, JK, T, and D latches and flip-flops, master slave JK flip-flop, edge-triggered flip-flop, synchronous and asynchronous counters, finite-state machine, sequence detector, minimization and transformation of sequential machines, Registers, Verilog models

Testing of Combinational circuits: Fault models, structural testing: path sensitization Logic families: TTL and CMOS Logic circuits, Transfer characteristics, fan-in, fan-out, noise margin, rise time and fall time analysis, realization of Boolean equations using CMOS logic

Memory: Types of memories, MOS SRAM cells, DRAM, SDRAM, ALL DDRx, organization of a SRAM, Organization of SDRAM, Periphery circuitry of Memory, Flash memory, SD card

Learning Resources:

Text Books:

1. William J. Dally and John W. Poulton, Digital Systems Engineering, Cambridge University Press, 2008.
2. Schilling, Herbert Taub and Donald, Digital Integrated Electronics, Tata McGraw-Hill, 2008.
3. Digital Design: With an Introduction to the Verilog HDL, VHDL, and System Verilog, 6th edition.
4. Jayaram Bhasker, Verilog Primer, Prentice-Hall India, 1998,3rd edition.

Refence Books:

1. Sameer Palnitkar, Verilog HDL: A guide to digital Design and Synthesis, Pearson, 2003, 2nd edition.
2. John F Wakerly, Digital Design Principles and Practices, Prentice Hall India, 2001, 3rd Edition.
3. Franklin P. Processor, David E. Winkel, The Art of Digital Design: An Introduction to Top-Down Design, PTR Prentice Hall, 1987, 2nd Edition.

EC1207 **3-0-0 (3)**

Networks and Transmission Lines

Pre-Requisites: **None**

Course Outcomes: At the end of the course, the student will be able to:

CO-1	Understand the concept of impedance matching and its significance
CO-2	Design filters and equalizers for given applications
CO-3	Analyse and interpret the voltage and current distributions on the transmission lines
CO-4	Use the Smith chart as a graphical tool to solve impedance-matching issues

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	-	-	1	-	1	-	-	-	-	-	-	1	2	-
CO-2	-	2	2	-	1	-	-	-	-	-	-	1	2	-
CO-3	3	-	2	3	1	-	-	-	-	-	-	1	2	-
CO-4	2	-	2	-	1	-	-	-	-	-	-	1	2	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

NETWORKS: Image and iterative impedances, image and iterative transfer constants, insertion loss, attenuators, lattice networks and their parameters, impedance matching networks, and networks designed for specified phase shifts.

FILTERS: Filter fundamentals, Low pass, high pass, band pass, and band elimination filters, Constant K and m derived sections, and composite filters.

EQUALISERS: Inverse impedances, series and shunt equalizers, L-type equalizers, T and Bridged T equalizers, and lattice equalizers.

TRANSMISSION LINE THEORY: Primary and secondary constants, phase and Group velocities, transmission line equations, distortion, and line loading

RF LINES: RF lines, lossless lines, reflection coefficient, and VSWR. Quarter-wave, half-wave, and 1/8-wave lines. Smith chart— lumped element matching, Impedance matching with single and double stubs.

Learning Resources:

Text Books:

1. John D Ryder , Networks, Lines and Fields, Prentice Hall, 1970.
2. Johnson, Transmission Lines and Networks, Mc-Graw Hill, 1950.

Reference Books:

1. E.V.D. Glazier and H.R.L. Lamont, Transmission and Propagation, The Services' Textbook of Radio Volume 5, 1958, 1st Indian Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/106/108106157/
2. https://nptel.ac.in/courses/117/101/117101057/

EC1209 **0-1-2 (2)**

Electronic Circuits and Analysis Lab

Pre-Requisites: **EC1201**

Course Outcomes:

CO-1	Synthesize and evaluate single stage and two stage amplifiers
CO-2	Design and test differential amplifier
CO-3	Realize the given performance using feedback amplifiers
CO-4	Design and test Oscillator circuits using BJT and FET.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	3	-	-	2	-	-	-	2	-	-	2	1	1
CO-2	-	3	2	2	2	-	-	-	2	-	-	2	1	1
CO-3	-	3	2	2	2	-	-	-	2	-	-	2	1	1
CO-4	-	3	2	2	2	-	-	-	2	-	-	2	1	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

LIST OF EXPERIMENTS:

All the experiments must be performed on Hardware and Simulation platform.

1. Single stage BJT and MOSFET amplifier
2. Differential amplifier
3. Two stage BJT amplifier
4. Cascode amplifier
5. Voltage series feedback amplifier
6. Voltage shunt feedback amplifier
7. Current series feedback amplifier
8. Current shunt feedback amplifier
9. RC phase shift oscillator
10. Wein bridge oscillator
11. Hartley and colpitts oscillator
12. Mini project on Multistage/Differential/Feedback Amplifiers

Learning Resources:

Text Books:

1. Donald Neamen, Microelectronics Circuit Analysis and Design, McGrawHill,2010,4th Edition.

2. Richard C Jaeger and Travis N Blalock, Microelectronic Circuit Design, McGraw Hill, 2016, 5th Edition.

Reference Books:

1. Robert L Boylestad and Louis Nashelsky, Electronic Devices and Circuit Theory Pearson, 2013, 11th Edition.
2. Adel S Sedra, K C Smith and A N Chandorkar, Microelectronic Circuits: Theory and Applications, Oxford University Press, 2017, 7th Edition.
3. Ben Streetman, Solid State Electronic Devices, Pearson, 2015, 7th Edition.
4. David A Bell, Electronic Devices and Circuits, Oxford publication, 2008, Fifth Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/117/105/117105147/
2. https://nptel.ac.in/courses/117/108/117108038/
3. https://onlinecourses.nptel.ac.in/noc21_ee86/preview

EC1211 **0-1-2 (2)**

Digital Circuit Design Lab

Pre-Requisites: **EC1205**

Course Outcomes:

CO-1	Develop data flow, behavioural and structural Verilog models for digital circuits
CO-2	Compile and Simulate Verilog models of digital circuits using CAD tool
CO-3	Synthesize subsystems/ modules using CAD tool
CO-4	Implement digital circuits on FPGA prototype boards

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	-	2	3	-	2	-	-	-	2	-	-	1	1	2
CO-2	-	2	3	-	2	-	-	-	2	-	-	1	1	2
CO-3	-	3	2	-	2	-	-	-	2	-	-	1	1	2
CO-4	-	3	2	-	2	-	-	-	2	-	-	2	1	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

List of Experiments:

1. Develop dataflow Verilog models for

   a) 2-to-4decoder

   b) 8-to-3encoder

   c) 4:1 mux

   d) full adder/subtractor

   e) 8-bit parity generator/checker

   f) 8-bit Kogge-stone adder

Develop structural Verilog models for

a) 16:1 mux realization using 4:1mux

b) 4-bit ripple carry adder using full adder

c) 8-bit adder using 4-bit ripple carry adder

d) 8-bit carry select adder using 4-bit ripple carry adder

e) 16-bit adder by cascading an 8-bit Kogge-stone adder/Ripple carry adder

f) 4-bit asynchronous up/down counter

g) 16-bit Universal shift register

2. Develop Verilog models for implementation of the following modules using top-down design style

a) Serial Adder

b) 16-bit Modified Booth's multiplier

c) 16-bit Vedic multiplier

3. Mini Project

Learning Resources:

Text Books:

1. M.Morris Mano and Michel. D. Ciletti, Digital Design with an introduction to HDL, VHDL and Verilog, Pearson education, Sixth edition.
2. R. Anand, Digital System Design Using VHDL, Khanna Book Publishing Company.
3. R. Anand, Digital Electronics, Khanna Book Publishing Company.
4. R.P. Jain, —Modern digital Electronics‖, Tata McGraw Hill, 2009, 4th edition.
5. Douglas Perry, —VHDL‖, Tata McGraw Hill, 2002, 4th edition.

Reference Books:

1. W.H. Gothmann, —Digital Electronics- An introduction to theory and practice‖, PHI,2006, 2nd edition.
2. D.V. Hall, —Digital Circuits and Systems‖, Tata McGraw Hill, 1989.
3. Charles Roth, —Digital System Design using VHDL‖, Tata McGraw Hill, 2012, 2nd edition.

4th Semester

MS1262 **3-0-0 (3)**

Business Essentials for Engineers

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the basic concepts of management and its functions
CO-2	Apply the functions of management for taking effective decisions
CO-3	Analyze factors influencing management in competitive business environment
CO-4	Identify business opportunities and challenges
CO-5	Integrate functions of management for building a better organization

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	-	-	-	-	-	-	-	-	3	-	3	3	-	-
CO-2	-	-	-	-	-	-	-	-	2	-	3	3	-	-
CO-3	-	-	-	-	-	-	-	-	1	-	3	3	-	-
CO-4	-	-	-	-	-	-	-	-	1	-	2	2	-	-
CO-5	-	-	-	-	-	-	-	-	1	-	1	2	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: The evolution of management theory, Business functions and their roles, Organizations and types, Levels of management, Types of markets and pillars of management- planning, organizing, leading and controlling.

People Management: Catalysts for organizational performance – Motivation & Leadership, Organization culture & Change, Human resource functions in a dynamic business environment and evolving dynamics in Industrial Relations.

Marketing Management: Nature and scope of marketing, Company's orientation towards market place, Importance of marketing concept, Marketing environment, 4p's of marketing, market segmentation, target market selection and positioning.

Financial Management: Financial accounting, Financial statements and analysis for decisions, Financial planning, Capital, Working capital, Capital structure and Sources of corporate finance, Investment decisions.

Project Management: Project screening and Selection, Techniques, Structuring concepts and Tools (WBS, OBS, and LRC, RACE). Project life cycle analysis. Appraisal of a project, Project Planning: Techniques, CPM, PERT- GAN - Time Cost Trade-off and Crashing Procedure, Project Monitoring: Monitoring Techniques and time control System, EVA Analysis

Quality & Strategy: Quality, Principles, Quality Awards, Standards of Quality culture, Quality metrics programs, Strategy, Vision and Mission, Porter's 5–forces, McKinsey's 7S Model, BCG Matrix, Competitive advantage - Value chain analysis & Resource based view.

Learning Resources:

Text Books:

1. Ronald J. Ebert, Ricky W. Griffin, Business Essentials, Pearson, 2019, 12th Edition
2. Harold Koontz, Heinz Weihrich, Mark V. Cannice, Essentials of Management, McGraw hill, 2020, 11th Edition

Reference Books:

1. G. Shainesh Philip Kotler, Kevin lane Keller, Alexander Chernev, Jagdish N. Sheth, Marketing Management, Pearson, 2022, 16th Edition
2. Dessler, G., & Varkkey, B, Human Resource Management, Pearson Education, 2024, 17th Edition
3. Prasanna Chandra, Financial Management: Theory & Practice, Mc Graw Hill, 2022, 11th Edition
4. Poornima M Charantimath, Total Quality Management, Pearson, 2022, 4th Edition
5. IM Pandey, Financial Management, Vikas Publications, 2021, 12th Edition
6. Jack R. Meredith, Mantel, Project Management - A Managerial Approach, John Wiley, 2021,11th Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/110106050
2. https://nptel.ac.in/courses/110105146
3. https://nptel.ac.in/courses/110105069
4. https://nptel.ac.in/courses/110104068
5. https://ocw.mit.edu/courses/15-535-business-analysis-using-financial-statements-spring-2003/
6. https://ocw.mit.edu/courses/15-810-marketing-management-fall-2010/

EC1202 **3-0-0(3)**

Digital System Design

Pre-Requisites: **EC1205**

Course Outcomes:

CO-1	Understand the FPGA based design flow
CO-2	Explore the different FPGA Fabric architectures
CO-3	Summarize various delays in combinational circuit and its optimization methods.
CO-4	Construct combinational and sequential circuits of medium complexity that is based on VLSIs and programmable logic devices.
CO-5	Summarize the advanced topics such as reconfigurable computing, partially reconfigurable and Pipeline reconfigurable architectures.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	-	-	2	1	1	-	3	-	2	-	-	2	2	-
CO-2	-	-	2	1	3	-	3	-	2	-	-	1	2	-
CO-3	-	-	2	1	2	1	1	1	2	1	-	2	2	-
CO-4	-	-	2	1	2	-	3	-	2	-	-	-	2	-
CO-5	-	-	2	3	2	-	-	-	-	-	-	1	2	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Chapter 1 FPGA-based systems: Goals and Techniques, Hierarchical Design, Design abstractions, Methodologies, role of FPGAs, FPGA types, FPGA vs, Custom VLSI

Chapter 2 FPGA Fabrics: FPGA Architectures, SRAM based FPGAs, Flash based FPGAs, Circuit design of FPGA fabrics, Architecture of FPGA fabrics

Chapter 3 Combinational Logic: Logic design process, HDLs, Arithmetic logic Adders, Multipliers, and combinational shifters, ALUs, Logic implementation for FPGAs, Syntax -directed translation, logic implementation by macro, logic synthesis, technology dependent logic optimization, Technology independent logic optimizations.

Chapter 4 Sequential Machines: Sequential machine design process, sequential design styles State transition and register transfer models, Algorithmic state Machines (ASM), ASM chart notations, Traditional synthesis for ASM charts and Multiplexer controller method, One -hot method and ROM based method. Clocking disciplines, performance analysis, clock skew, retiming, and power optimization. Design Examples: Shift and add multiplier, Booth's multiplier, Modified booth's multiplier, Restoring and Non-restoring divider, Barrel shifter, floating point arithmetic operations.

Chapter 5 Architecture Design & Testing: Data-path and controller architectures, pipeline design, Design methodologies, Design processes, Design Standards, Design Verification. Design Testing –Combinational Logic Testing, Sequential Logic design testing. BIST Architectures.

Learning Resources:

Text Books:

1. M. Morris Mano, Michael D. Ciletti, Digital Design: With an Introduction to the Verilog HDL, VHDL, and SystemVerilog, Pearson, 2022, 6th Edition
2. W. Wolf, FPGA- based System Design, Pearson,2004.
3. Franklin P. Processor, David E. Winkel, The Art of Digital Design: An Introduction to Top- Down Design, PTR Prentice Hall, 1987, 2nd Edition.
4. C. Roth, “Fundamentals of Digital Logic Design”, Jaico Publishers, 2009, 5th Edition.

Reference Books:

1. S. Hauck, A.DeHon, ”Reconfigurable computing: the theory and practice of FPGA-based computation”, Elsevier, 2008.
2. John V. Old Field, Richrad C. Dorf, Field Programmable Gate Arrays, Wiley, 2008.
3. R.F.Tinde,” Engineering Digital Design”, (2/e), Academic Press,2000.
4. C. Bobda, “Introduction to reconfigurable computing”, Springer, 2007.
5. M. Gokhale,” Paul S. Graham, Reconfigurable computing: accelerating computation with field- programmable gate arrays”, Springer,2005.

EC1204 **3-0-2 (4)**

Probability Theory and Stochastic Processes

Pre-Requisites: **None**

Course Outcomes:

CO-1	Distinguish between random variable and stochastic processes
CO-2	Obtain density and distribution functions for derived random variables
CO-3	Characterize LTI systems driven by a stationary random process using autocorrelation and power spectral density functions.
CO-4	Model communication system as a stochastic process.
CO-5	Model the Probability and Stochastic processes and Visualize their principles through simulation

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	–	1	–	–	–	–	–	–	–	–	1	1	–
CO-2	3	2	1	–	–	–	–	–	–	–	–	2	1	–
CO-3	3	2	1	–	–	–	–	–	–	–	–	1	1	–
CO-4	3	2	1	–	–	–	–	–	–	–	–	1	1	–
CO-5	3	2	1	–	–	–	–	–	–	–	–	1	1	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Axioms of Probability, Probability Space, Conditional Probability, Bayes Theorem, Repeated Trails, Bernoulli ‘s Trails.

Concept of a Random Variable: Distribution and density functions, Properties of distribution functions, Continuous type random variable, Normal, Exponential, uniform, Binomial, Poisson distributions, Negative binomial distributions. Conditional distributions, Total probability and Bayes theorem.

Functions of one random variable: Distribution and Density Functions, Expectation, Variance, Moments, Characteristic functions.

Two Random Variables: One Function of Two Random Variables, Two Functions of Two Random Variables, Joint Moments, Joint Characteristic Functions, Conditional Distributions, Conditional Expected Values.

Stochastic Processes: Concept of Stationarity, Distribution and Density Functions, Statistical Independence, Auto correlation function and its properties, Cross- correlation Function and its Properties, Covariance functions Time Averages and Ergodicity, Mean Ergodic Process, Discrete Time Processes and Sequences, Power Density Spectrum and its Properties. Linear systems with random inputs.

Lab Experiments:

1. Write a MATLAB program to find probability of tossing a coin and rolling a die through large no. of experimentation.
2. Generate Uniform, Gaussian and Exponential distributed random data for given mean and variance.
3. Write a MATLAB program to generate M trials of a random experiment having specific number of outcomes with specified probabilities.
4. To find estimated and true mean of Uniform, Gaussian and Exponential distributed data.
5. To find density and distribution function of a function of random variable Y = 2X + 1. Where X is Gaussian R.V.
6. Estimate the mean and variance of Y = 2X + 1, where X is a Gaussian random variable.
7. Plot Joint density and distribution function of sum of two Gaussian random variable (Z = X + Y).
8. Estimate the mean and variance of a R.V. Z = X+Y. Where X and Y are also random variables.
9. Simulation of Central Limit Theorem.
10. Write two MATLAB functions to generate samples of stationary Gaussian processes.
11. Write three MATLAB functions to generate samples of non-stationary Gaussian processes.
12. Verify relations between correlation and power spectral density using MATLAB simulation.

Learning Resources:

Text Books:

1. P.Z. Peebles.Jr., Probability, Random Variables AND Random Signal Principles, Tata McGraw Hill Education, 2017, 4th Edition.
2. A.Papoulis, Probability, Random variables and Stochastic Processes, McGraw Hill, 2017, 4th Edition,.
3. Scott Miller, Donald Childersm, Probability and Random Processes, Elsevier, 2012, 2nd Edition.

Reference Books:

1. Athanasios Papoulis and S., Unnikrishna Pillai. Probability, Random Variables and Stochastic Processes, TMH, 2002, 4th Edition.
2. Pradip Kumar Gosh, Theory of Probability and Stochastic Processes, University Press.
3. Henry Stark and John W. Woods, Probability and Random Processes with Application to Signal Processing, PE, 3rd Edition.
4. S.P. Eugene Xavier, Statistical Theory of Communication, 1997, New Age Publications.

Other suggested Readings:

1. https://nptel.ac.in/courses/111102111

EC1206 **3-0-0 (3)**

Electromagnetic Fields and Waves

Pre-Requisites: **None**

Course Outcomes:

CO-1	Solve Maxwell's equations using vector calculus in three standard coordinate systems
CO-2	Deduce EM wave propagation in free space and in dielectric medium
CO-3	Analyze electromagnetic wave propagation in guiding structures under various matching conditions
CO-4	Understand the power flow mechanism in guiding structures and in unbounded medium

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	–	–	1	–	–	–	–	–	–	–	–	1	1
CO-2	2	2	–	–	1	2	–	–	–	–	–	–	1	1
CO-3	2	2	–	–	1	–	–	–	–	–	–	–	1	1
CO-4	3	–	–	1	–	2	–	–	–	–	–	–	1	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Static Electric and Magnetic Field Review: Introduction to coordinate systems, Gauss's law, gradient, electric scalar potential, electric dipole, divergence of flux density, divergence theorem. Characteristics of dielectrics, boundary relations. Poisson's and Laplace Equations, Biot Savart law, Ampere's law, Comparison of divergence and curl, magnetic vector potential

Maxwell's Equations: Faraday's Law, Lenz Law. The equation of continuity for time-varying fields, Maxwell's equations in differential, integral, and phasor forms, Conditions at a boundary surface,

Plane waves: Wave equations, plane waves in dielectric media, Plane waves in conducting media, polarization, skin effect, reflection of plane waves: Reflection of normally and oblique plane waves from conductors and dielectrics, total reflection. Poynting theorem, power flow for a plane wave, and power loss in a plane conductor

Guided Waves: Waves between parallel planes, TE and TM waves, Characteristics of TE and TM waves, TEM waves, Velocities of propagation, Attenuation in parallel plane guides, Wave impedance, Electric field, and current flow within the conductor.

Wave Guides: Rectangular wave guides, TE and TM modes in wave guides, Velocity, wavelength, impedance, and attenuation in rectangular waveguides.

Learning Resources:

Text Books:

1. E.C.Jordan and K.G.Balmain, Electromagnetic waves and Radiating Systems, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1968.
2. John D.Kraus, Electromagnetics, McGraw Hill Book Co., 1991.

Reference Books:

1. Nathan Ida-Engineering Electromagnetics, 2020, Springer (India) Pvt. Ltd., New Delhi, 4th Edition.
2. William H. Hayt Jr. and John A. Buck-Engineering Electromagnetics, McGraw-Hill,2018, 9th Ed.
3. Matthew N.O. Sadiku and S.V. Kulkarni, Principles of Electromagnetics, Oxford University Press, Aisan Edition, 2015, 6th Ed.

EC1208 **3-0-0 (3)**

Linear IC Applications

Pre-Requisites: **None**

Course Outcomes:

CO-1	Design op-amp circuits to perform arithmetic operations
CO-2	Analyze and design linear and non-linear applications using op-amps.
CO-3	Analyze and design oscillators and filters using functional ICs.
CO-4	Choose appropriate A/D and D/A converters for signal processing applications.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	3	2	–	–	–	–	–	1	–	–	–	1	–
CO-2	2	3	2	–	–	-	–	–	1	–	–	–	1	–
CO-3	1	2	2	–	–	–	–	–	1	–	–	–	1	–
CO-4	1	2	–	–	2	-	–	–	1	–	–	2	1	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Op Amp: Introduction to op-amps, ideal Characteristics, Pin configuration of 741 op-amps. Bias, offsets and drift, bandwidth and slew rate. Offset and Frequency compensation. Inverting and non-inverting amplifiers and their analysis, Applications: inverting and non-inverting summers, difference amplifier, differentiator and integrator, solving differential equations.

Op-Amp Applications: Instrumentation amplifier, RC-phase shift oscillator, Wein ‘s bridge oscillator, Log and antilog amplifiers. Analog IC Multipliers and dividers, Comparators, Schmitt triggers, Square wave Generators, Triangular wave- generators. Active Filters, Low pass, High pass, Band pass and Band Reject filters, Butterworth, Chebyshev filters, Different first and second-order filter Topologies,

Timer: 555 Timer functional diagram, monostable and astable operation, applications.

ADCs and DACs: Weighted resistor DAC, R-2R DAC. IC DAC-08. counter type ADC, successive approximation ADC, Flash ADC, dual slope ADC, conversion times of typical IC ADC

Other Linear ICs: Voltage Regulators Voltage Regulator Series op amp regulator, Three terminal IC voltage regulator exercise problems. IC 723 general purpose regulator, Switching Regulator. Phase Locked Loop PLL- basic block diagram and operation, capture range and lock range; IC 565, VCO IC 566.

Learning Resources:

Text Books:

1. G B Clayton, Operational Amplifiers, Elsevier science, 2003, 5th Edition.
2. Sergio Franco, Design with Operational Amplifier and Analog Integrated Circuits, TMH, 2017, 4th Edition.

3. Roy Choudary D. and Shail B. Jain, Linear Integrated circuits, New Age International Publishers, 2017, 4th Edition.
4. Ramakant A.Gayakward, Op-Amps and Linear Integrated Circuits, PHI, 2015, 4th Edition.

Reference Books:

1. Operational Amplifiers & Linear Integrated Circuits, R.F. Coughlin & Fredrick F. Driscoll, PHI, 2000,6th Edition.
2. Denton J. Daibey, Operational Amplifiers & Linear Integrated Circuits: Theory & Applications, TMH.

EC1210 **0-1-2 (2)**

IC Applications Lab

Pre-Requisites: **EC1208**

Course Outcomes:

CO-1	Measure the parameters of IC 741 Op-amp and realize applications such as Integrators, differentiators, filters, and waveform generators
CO-2	Plot the characteristics of TTL NAND Gate
CO-3	Design monostable and astable multivibrators using 555 IC.
CO-4	Use digital TTL & CMOS ICs and build applications
CO-5	Use ICs such as 7805 and 723 to design DC power supplies

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	-	2	1	–	–	–	–	–	2	–	–	–	1	–
CO-2	2	3	1	–	–	-	–	–	2	–	–	–	1	–
CO-3	-	2	1	–	–	–	–	–	2	–	–	–	1	–
CO-4	-	3	1	–	-	-	–	–	2	–	–	-	1	–
CO-5	-	3	1	–	–	–	–	–	2	–	–	–	1	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

List of Experiments:

1. Study and Operation of IC testers, pulse generator and digital trainer.
2. Study of logic gate ICs and their applications
3. Frequency response of inverting and non-inverting amplifier.
4. Measurement of Op-amp parameters: (i) Input Offset voltage (ii) Input Offset current (iii) CMRR and (iv) Slew rate iv) PSRR
5. Op Amp Integrator and Differentiator and its frequency response
6. Characteristics of TTL NAND gate: (i) Sourcing (ii) Sinking (iii) Transfer
7. Verify the functionality of Mux and Decoder ICs and their application.
8. Verify the functionality of Flip-Flop ICs and its application.
9. Mod-N counter using 7490 and 74190. Mod-N counter using 7492 and 74192
10. 555 timers: Monostable and astable multivibrators.
11. Shift register IC 7495.
12. 7805 as Fixed and variable voltage regulator & voltage regulator IC 723.
13. 2nd order Active filters and frequency response.

Learning Resources:

Text Books:

1. Ramakant A.Gayakward, Op-Amps and Linear Integrated Circuits, PHI, 2015, 4th Edition.

EC1212 **0-1-2 (2)**

Digital System Design Lab

Pre-Requisites: **EC1202**

Course Outcomes:

CO-1	Understand the Verilog HDL in different level of abstractions
CO-2	Develop Verilog model for given combinational circuit
CO-3	Develop Verilog model for given sequential circuit
CO-4	Design and develop a Verilog model for a complex system

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	-	-	-	1	-	-	-	2	-	1	-	2	-
CO-2	3	-	-	-	1	2	-	-	2	-	1	1	2	-
CO-3	3	-	-	-	1	-	-	-	2	-	1	-	2	-
CO-4	2	3	-	-	1	-	-	-	2	-	1	-	2	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Module 1: Design and Implementation of the following Sequential HDL models on Xilinx Nexus 4DDR Artix7 FPGA

a) Sequence Detector

b) Synchronous/Asynchronous Counters

c) Universal Shift Register

d) Sequence Generator

e) Traffic Light Controller

f) Vending Machine Controller

Module 2: Top-down design and implementation of the following logic circuits data path and Controller on Xilinx Nexus 4DDR Artix7 FPGA:

a) Serial Adder

b) Shift-and-add Multiplier

c) Booth's Multiplier

d) Array Multiplier

e) Restoring and Non-Restoring Division

f) Floating-Point Adder/Subtractor

g) Floating -Point Multiplier

h) Floating-Point Divider

i) 8-Bit ALU

Module 3: Mini Project

Learning Resources:

Text Books:

1. Samir Palnithkar, Verilog HDL A guide to digital Design and Synthesis, Pearson, 2003, 2nd edition.
2. M. M. Mano and Michael D. Ciletti, Digital Design with an Introduction to the Verilog HDL, VHDL, and System Verilog, Pearson, 2018, Sixth Edition.
3. C. H. Roth, L. K. John, B. K. Lee, Digital System Design using Verilog Fundamentals of Logic Design, Mindtap Cengage Publishers, 2016.
4. S. Brown and Z Vranesic, Fundamentals of Logic Design with Verilog Design, Tata McGraw-Hill,2017, 2nd Edition.

Other suggested Readings:

1. https://nptel.ac.in/courses/106/105/106105165/

5th Semester

EC1301 **3-0-2 (4)**

Data Networks

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify and explain the fundamental concepts of network architecture, protocols and internetworking principles.
CO-2	Design a data communication link considering fundamental concepts of stop & wait, go-back-n and selective repeat link layer concepts and framing.
CO-3	Design and build Local Area Networks considering the shared medium choices for high-speed LANs or Wireless LANs.
CO-4	Understand the concepts of Wide Area Networks, such as switching, routing, congestion, and network management.
CO-5	Understand the concepts of media access control, IP addressing, packet forwarding, queueing, and process-to-process communication.
CO-6	Design networks with good quality-of-service and security.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	–	–	–	–	–	–	–	–	–	–	2	–
CO-2	2	3	3	2	1	–	–	–	–	–	–	–	2	2
CO-3	3	3	3	–	3	–	–	–	–	–	–	–	2	2
CO-4	1	2	–	2	–	–	–	–	–	–	–	–	2	–
CO-5	1	2	2	3	3	3	–	–	–	–	–	3	3	3
CO-6	3	2	3	3	3	3	3	–	–	–	–	3	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Basics of Data Communications for networking; Packet switching, Store-&-Forward operation; Layered network architecture, Overview of TCP/IP operation.

Data Link layer: Framing; error control, error detection, parity checks, Internet Checksum and Cyclic Redundancy Codes for error detection; Flow control, ARQ strategies and their performance analysis using different distributions; HDLC protocol. Media Access Control (MAC): MAC for wired and wireless Local Area Networks (LAN), Pure and Slotted ALOHA, CSMA, CSMA/CD, IEEE802.3; ETHERNET, Fast ETHERNET, Gigabit ETHERNET; IEEE 802.11 WiFi MAC protocol, CSMA/CA.

Network Layer: Routing algorithms, Link State and Distance Vector routing; Internet routing, RIP, OSPF, BGP; IPv4 protocol, packet format, addressing, subnetting, CIDR, ARP, RARP, fragmentation and reassembly, ICMP; DHCP, NAT and Mobile IP; IPv6summary.

Transport Layer: UDP, segment structure and operation; TCP, segment structure and operation. Reliable stream service, congestion control and connection management.

Network Security and Internet Applications: Security Requirements and Attacks, Confidentiality with Conventional Encryption, Message Authentication and Hash Functions, Public-Key Encryption and Digital Signatures, Secure Socket Layer and Transport Layer Security, IPv4 and IPv6 Security.

Selected Application layer Protocols: Web and HTTP, electronic mail (SMTP), file transfer protocol (FTP), Domain Name Service (DNS). Real-Time Traffic, Voice Over IP and Multimedia.

List of Experiments

1. Understanding the basic networking commands and their operation in Windows and Linux.

2. Understanding the hardware used for networking like routers, switches, LAN cables, connectors, fibre, access points, network interface cards, zigbee cards, bluetooth cards, broadband modems, etc.

3. Study and analyze the design concept and working principle of NITW campus network.

4. Simulation of Computer Networks using Network Simulation software. It makes possible to build, configure networks and verify its availability.

5. Understanding link layer, IP and TCP using Network monitoring software. It supports Ethernet, FDDI, Token Ring, ISDN, PPP, SLIP and WLAN devices, plus several encapsulation formats. Node statistics can be exported.

6. Network Socket programming: TCP/UDP Client-Server program.

7. Analyzing the network traffic using network analyzer software – Wireshark.

8. Simulation of Data Link layer protocols in Matlab. a) Stop and wait (with and without errors) b) Go-back-N (with and without errors) c) Selective repeat (with and without errors) d) Sliding window (with and without errors)

9. Simulation of wired network using Network Simulator NS2.

10. Simulation of Wireless networks (Wifi & Bluetooth) using NS2.

Learning Resources:

Text Books:

1. Behrouz A. Forouzan, Data Communications and Networking, Tata McGraw-Hill, New Delhi,2006, 4th Edition,
2. D. Bertsekas and R. Gallager, Data Networks, PHI,1992, 2nd edition.

Reference Books:

1. J.F. Kurose and K. W. Ross: Computer Networking, A Top-Down Approach, Pearson/Addison Wesley,2016, 7/e.
2. W. Stallings, Data and Computer Communication, Prentice-Hall,2017, 10/e.

Other suggested Readings:

1. NPTEL Course: NOC:Computer Networks and Internet Protocol, IIT Kharagpur, Prof. Soumya Kanti Ghosh, Prof. Sandip Chakraborty
2. A. S. Tanenbaum, Computer Networks, PHI,2013, 5/e.
3. Douglas E Comer, Computer Networks and Internet, Pearson Education Asia, 2000.
4. A. Leon-Garcia and I. Widjaja: Communication Networks; McGraw Hill,2017, 2nd Edition.

EC1303 **3-0-0 (3)**

Analog Communications

Pre-Requisites: **EC1203**

Course Outcomes:

CO-1	Compare the performance of AM, FM and PM schemes with reference to SNR
CO-2	Understand noise as a random process and its effect on communication receivers
CO-3	Evaluate the performance of PCM, DPCM and DM
CO-4	Understand FDM & TDM multiplexing techniques

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	2	-	-	2	-	-	-	1	-	-	2	1	1
CO-2	-	-	-	-	2	-	-	-	-	-	-	-	1	1
CO-3	-	1	2	2	3	-	-	-	1	-	-	1	1	1
CO-4	-	1	-	-	3	-	-	-	1	-	-	1	1	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Introduction to Communication Process, Communication Channels,Modulation, Analog vs Digital signals, Review of Signals and Systems

Modulation Techniques: Amplitude Modulation (AM), Envelop Detection, Limitations of AM, DSB-SC Modulation, Coherent Detection, SSB, Frequency Division Multiplexing, Angle Modulation, Frequency Modulation, Narrowband FM, Generation of FM, Detection of FM, Phase locked Loop (PLL); FDM Transmission of Random Process through an LTI filter, PSD, Properties of PSD. NoiseFigure, Noise Bandwidth, Noise Temperature**.** Noise in AM Receivers, Noise in FM, Pre - emphasis, De-emphasis in FM.

Pulse Modulation — Sampling process, Sampling theorem, Pulse Amplitude Modulation. TDM, Pulse width Modulation, Pulse Position Modulation.

Analog-to-Digital signal conversion: Quantization Process, Quantization Noise, PCM. PCM encoding generation and decoding, Delta Modulation, Adaptive Delta Modulation, Differential Pulse-code Modulation.

Base Band Shaping for Data Transmission: Requirements of a line encoding format, various line encoding formats- Unipolar, Polar, Bipolar, Discrete PAM signals, inter symbol interference, Nyquist's criterion, Raised cosine filter.

Source Coding: Uncertainty, Information & Entropy, Source coding theorem, Huffman coding. Channel Capacity: Channel capacity, Shannon Hartley law, channel coding theorem, channel capacity theorem.

Learning Resources:

Text Books:

1. Simon Haykin, Communication Systems, Wiley India Pvt. Ltd, 2009, 5th Edition.
2. Simon Haykin, An Introduction to Analog and Digital Communications, Wiley India Pvt. Ltd, 2006, 2nd Edition.

Reference Books:

1. B P Lathi, & Communication Systems&, PHI Learning pvt ltd India, 2001, 2 nd Edition
2. K.C. Raveendrana, Analog Communications Systems principles and practices, Universities Press, , 2009, First Edition
3. T G Thomas and S Chandra Sekhar, Communication Theory&, McGraw-Hill companies, 2006, First Edition

Other suggested Readings:

1. https://nptel.ac.in/courses/117/105/117105143/
2. https://nptel.ac.in/noc/courses/noc17/SEM2/noc17ec11/
3. https://onlinecourses.nptel.ac.in/noc21_ee74/preview

EC1305 **3-0-0 (3)**

Digital Signal Processing

Pre-Requisites: **EC1203**

Course Outcomes:

CO-1	Identify, formulate, and solve engineering problems in the area of signal processing.
CO-2	Implement FFT algorithms for computing the DFT
CO-3	Design and implementation of FIR and IIR filters.
CO-4	Apply down and up sampling techniques in designing of advanced digital signal processing systems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	1	1	2	–	–	–	1	–	–	–	3	2
CO-2	3	3	2	2	2	–	–	–	1	–	–	–	2	2
CO-3	3	3	3	3	2	–	–	–	1	–	–	2	2	2
CO-4	3	3	3	3	2	–	–	–	1	–	–	2	2	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Discrete Fourier Transform (DFT): The DFT & its properties; Inverse DFT, Linear filtering methods based on DFT - Use of DFT in linear filtering, filtering of long data sequences, Efficient computation of DFT algorithms-Radix2 (DIT & DIF), Radix4, Split radix algorithms. Linear filtering approach to computation of DFT-Goertzel algorithm, Chirp z transform, Fast Fourier Transform (FFT)

Digital Filters: Linear phase FIR filter, characteristic response, location of zeros, Design of FIR filter-Windowing, Frequency sampling, Design of IIR filters from Analog filters-Impulse in variance, Bilinear transformation, Matched z-transform.

Digital Filter Structures: FIR filters - Direct form, Cascade form, Frequency sampling, Lattice IIR filter - Direct form I, Direct form II cascade form parallel form Lattice & Lattice loader,

Multirate Digital Signal Processing: Decimation by a factor D, Interpolation by a factor I, Sampling rate conversion by a rational factor I/D

DSP Processors: TMS C6xxx, Features, Architecture and Applications. Harvard Architecture, pipelining, Multiplier-Accumulator (MAC) Hardware. Architectures of Fixed- and Floating-point DSP processors. Addressing modes, functional modes. Memory architecture, on-chip peripherals of a DSP processor.

Learning Resources:

Text Books:

1. J. G. Proakis & D. G. Manolakis, Digital Signal Processing - Principles, algorithms & Applications, PHI,2000.
2. S. K. Mitra, Digital Signal Processing – A computer Based Approach, MGH, 2010, 4th Edition.

Reference Books:

1. A.V. Oppenheim and Ronald W. Schafer, Discrete Time Signal Processing, PHI,2000, 2nd Edition.
2. P. P. Vaidyanathan, Multi-Rate Systems and Filter Banks, Pearson Education.1993
3. Robert J. Schilling, Sandra L. Harris, Fundamentals of Digital Signal Processing using MATLAB, Thomson,2010, 2nd Edition.

Other suggested Readings:

1. Digital Signal Processing, IIT Delhi, Prof. S.C Dutta Roy, https://nptel.ac.in/courses/117102060.

EC1307 **3-0-0 (3)**

Microcontrollers

Pre-Requisites: **EC1202**

Course Outcomes:

CO-1	Understand the evolution of microprocessors and microcontrollers and its architectures
CO-2	Understand the evolution and architectures of ARM processors.
CO-3	Analyze and understand the instruction set and development tools of ARM
CO-4	Understand the architectural features of ARM cortex M4 microcontrollers.
CO-5	Understand the exception, interrupts and interrupt handling schemes
CO-6	Understand the hardware and interfacing peripheral devices to ARM cortex M4

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO- 10	PO- 11	PO- 12	PSO- 1	PSO-2
CO-1	2	3	1	-	2	-	-	-	-	-	2	1	1	1
CO-2	-	3	1	-	2	-	-	-	1	-	2	1	1	1
CO-3	-	3	1	-	-	-	-	-	1	-	2	1	2	2
CO-4	-	2	1	-	3	-	-	-	1	-	2	1	1	1
CO-5	-	2	1		3	-	-	-	1	-	-	-	2	2
CO-6	2	2	2		3	-	-	-	2	2	2	2	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Microprocessors and Microcontrollers: Evolution and introduction of 80X86 microprocessor, Architecture of 8086, Memory organization, 8086 system connections and timing. Overview of 8051 microcontroller, Architecture, Instruction set and addressing modes, RISC, IA86 and ARM

Introduction to Processors: Introduction to processors, Evolution of processors, pipeline organization, Processor cores and CPU cores. Introduction to ARM Cortex-M Processors, ARM Cortex-M4 processor ‘s architecture, Programmer ‘s model, Special registers, Operation Modes, Debug and Trace features. ARM references to be made generic

Assembly programming: Assembly basics, Instruction set, Data transfer, Data processing, conditional and branch instructions, barrier and saturation operations, Cortex-M4-specific instructions, Thumb2 instructions, Keil Microcontroller Development Kit for ARM, Typical program compilation flow, Sample arithmetic and logical assembly language programs

Memory Systems and interrupts: Overview of memory system features, Memory map, Memory access attributes and permissions, Data alignment and unaligned data access support, Bit-band operations, Overview of exceptions and interrupts, Exception types, Overview of interrupt management, Definitions of priority, Vector table and vector table relocation, Debug and reset sequence, Software interrupts, Exception

Handling.

Microcontroller and applications: Detailed block diagram of TM4C123GH6PM controller, Features, Bus interfaces, On-chip memory organization, on-chip peripherals GPIOs, Timers, UART, I2C, SPI, PWM, ADC programming. **Applications:** Flashing of LEDS, Interfacing stepper motor, Interfacing temperature sensor, Interfacing ADC, Interfacing Real Time Clock, Interfacing of Analog Key pad.

Learning Resources:

Text Books:

1. Joseph Yiu, The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors, Newnes Publications, 2013, Third Edition.
2. Ata Elahi-Trever Arjeski, ARM Assembly language with hardware experiment, Springer Int. Publishing, 2015.

Reference Books:

1. Steve Furber, ARM system on chip Architecture, Pearson Publications, 2000, Second Edition.
2. Douglas. V. Hall and SSSP Rao, Microprocessors and Interfacing, McGraw Hill Education, 2017.
3. James A. Langbridge, Professional Embedded ARM Development, Wrox publication, 2014
4. William Hohl and Christoper Hinds, ARM assembly language fundamentals and Techniques, CRC press, 2015, Second Edition.
5. M.A. Mazidi, J.G. Mazidi, R.D. Mckinlay, The 8051 Microcontroller and Embedded Systems, Pearson, 2017, Second Edition.

Other Suggested Readings:

1. https://onlinecourses.nptel.ac.in/noc22_cs93/preview
2. https://onlinecourses.nptel.ac.in/noc24_ee46/preview

EC1381 **1-0-0 (0.5)**

Fractal Course - I

Pre-Requisites: **None**

Course Outcomes:

CO-1	Acquire an in-depth understanding of the specific topic covered in the course, which could range from a particular technology, method, or recent advancement in Electronics and Communication Engineering.
CO-2	Develop hands-on skills relevant to the course topic, such as using specific tools, software, or techniques.
CO-3	Apply learned concepts to solve focused and practical engineering problems related to the course content
CO-4	Understand the interdisciplinary aspects and applications of the course to solve real-world industrial problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	3	-	-	-	-	-	-	-	-	-	1	2
CO-2	-	-	-	2	2	3	3	-	-	-	-	-	3	3
CO-3	-	-	3	2	2	-	-	-	-	-	-	-	3	3
CO-4	-	-	-	-	-	-	-	-	1	3	-	2	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

This one-week course aims to bridge the gap between academic learning and industry application / latest research developments, providing students with a comprehensive understanding of the Electronics and Communication engineering field and enhancing their readiness for professional careers.

a. **Structure:** Lectures delivered by an expert from the Electronics and Communication Engineering Industry / R&D Organization / Academic Institution (SPARK Collaborators / Foreign Subject Experts in GIAN program / Adjunct Professors from Foreign Universities @ NITW).
b. **Content:** Topics covering current practices, case studies, technological advancements, and future trends.
c. **Interactive Sessions:** Q&A sessions, discussions, and case study analyses to foster interaction between students and the subject expert.
d. **Assessment:** the mode of assessment (Participation, a short reflective report / a presentation summarizing key takeaways from the lectures / Objective or descriptive type exam, etc.) will be decided by the subject expert

Learning Resources:

1. Course material and any learning resources suggested by the experts

EC1309 **0-1-2 (2)**

Microcontrollers Lab

Pre-Requisites: **EC1307**

Course Outcomes:

CO-1	Understand the hardware and interfacing of peripheral devices to ARM cortex M4
CO-2	Write assembly language and C programs for arithmetic operations.
CO-3	Interface LED, ADC and DAC modules with microprocessor-based system
CO-4	Interface stepper motor, Keyboard and memory
CO-5	Interface wi-fi, IIC, SPI, and Bluetooth modules

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO- 10	PO- 11	PO- 12	PSO- 1	PSO-2
CO-1	2	3	1	-	2	-	-	-	2	2	2	1	1	1
CO-2	-	3	2	-	2	-	-	-	2	2	2	1	1	1
CO-3	-	3	2	-	2	-	-	-	2	2	2	1	2	2
CO-4	-	2	2	-	3	-	-	-	2	2	2	1	1	1
CO-5	-	2	2		3	-	-	-	2	2	-	-	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

List of Experiments:

1. Write a simple program for arithmetic operations – addition,
2. subtraction, multiplication and division of 16 or 32 – bit numbers
3. Flashing of LEDS using Shift Register
4. Interfacing ADC
5. Interfacing DAC
6. Interfacing 7-Segment LED.
7. Interfacing of Analog Key pad.
8. Interrupt using on board push button
9. Interfacing real time clock.
10. Interfacing stepper motor.
11. Interfacing temperature sensor.
12. Interfacing Bluetooth module.
13. Interfacing Real Time Clock
14. Interfacing of micro SD Card.
15. Interfacing Wi-Fi Module
16. Interfacing of IIC and SPI module

Learning Resources:

Text Books:

1. Joseph Yiu, The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors, Newnes Publications, 2013, Third Edition.
2. Ata Elahi-Trever Arjeski, ARM Assembly language with hardware experiment, Springer Int. Publishing, 2015.

Reference Books:

1. Steve Furber, ARM system on chip Architecture, Pearson Publications, 2000, Second Edition.
2. Douglas. V. Hall and SSSP Rao, Microprocessors and Interfacing, McGraw Hill Education, 2017.
3. James A. Langbridge, Professional Embedded ARM Development, Wrox publication, 2014
4. William Hohl and Christoper Hinds, ARM assembly language fundamentals and Techniques, CRC Press, 2015, Second Edition.
5. M.A. Mazidi, J.G. Mazidi, R.D. Mckinlay, The 8051 Microcontroller and Embedded Systems, Pearson, 2017, Second Edition.

Other suggested Readings:

1. https://onlinecourses.nptel.ac.in/noc22_cs93/preview
2. https://onlinecourses.nptel.ac.in/noc24_ee46/preview

EC1311 **0-1-2 (2)**

Digital Signal Processing Lab

Pre-Requisites: **EC1305**

Course Outcomes:

CO-1	Experiment concepts of DSP and its applications using MATLAB Software
CO-2	To understand about the basic signal generation
CO-3	To learn Fourier Transform Concepts
CO-4	To design FIR filters

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO- 10	PO- 11	PO- 12	PSO- 1	PSO-2
CO-1	2	1	-	-	1	-	-	-	2	-	-	2	2	2
CO-2	2	1	-	-	1	-	-	-	2	-	-	2	2	2
CO-3	-	2	-	-	1	-	-	-	2	-	-	1	2	2
CO-4	-	3	-	-	1	-	-	-	2	-	-	2	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

List of Experiments:

1. To perform basic arithmetic operations on DSP processor (TMS320C6748) low cost modules DSP IC,using the development environment (preferably open source)
2. To perform linear and circular convolution on DSP processor
3. To compute Discrete Fourier Transform (DFT) of discrete time sequence on DSP processor using CCS.
4. To compute Fast Fourier Transform (FFT) of discrete time sequence on DSP processor
5. To design FIR and IIR digital filter on DSP processor using CCS and MATLAB
6. To perform enhancement of image brightness and contrast using CCS on DSP processor
7. Image processing implementation on TMS320C6748

6th Semester

EC1302 **3-0-2 (4)**

Antennas and Propagation

Pre-Requisites: **None**

Course Outcomes:

CO-1	Provide an understanding of antenna radiating principle and discuss the fundamental characteristics and parameters of antennas.
CO-2	Develop the performance characteristics of antennas arrays, its operating principles, methods and concepts to design
CO-3	Simulation and Measurement of antenna parameters
CO-4	Understand the behavior of nature on EM wave propagation

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO- 10	PO- 11	PO- 12	PSO- 1	PSO-2
CO-1	3	-	-	-	1	-	2	-	1	-	-	-	2	
CO-2	-	2	-	-	1	1	1	-	1	-	-	-	2	2
CO-3	-	-	2	-	2	1	-	-	1	-	-	-	2	2
CO-4	3	1	1	1	1	-	-	-	1	-	-	-	2	

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Antenna Fundamentals: Introduction to antennas & their significance, Scalar electric potential, magnetic vector potential, radiation from an alternating current element, Induction field, radiation field, power radiated by a current element, Radiation mechanism of the infinitesimal dipole, power and its radiation resistance. Definition of an electric dipole, Power radiation and its radiation resistance of dipole, half-wave dipole, monopole and a quarter-wave monopole, Isotropic radiator, Radiation resistance of aerials and loop, related problems.

Antenna Parameters: Radiation pattern, power pattern, field pattern, Radiation intensity, beam width, field region, radiation power density, Directivity and gain, bandwidth, polarization, co polarization and cross-polarization level, input impedance, efficiency, antenna effective length and area, antenna temperature, scattering loss, network theorem, application of network theorem to antennas. Friss Transmission formula, Radar range equation.

Design of Arrays: Linear Array-Two element array, N-element linear array- broadside array, End fire array, Directivity, radiation pattern. Pattern multiplication, Effect of earth on vertical pattern mutual impedance effects. Non-uniform excitation- Binomial, Chebyshev distribution, Planar array – Array factor, Circular array - array factor, Directivity (Qualitative study), related problems.

Practical Antennas: Resonant & non-resonant antennas, Travelling wave antenna, V antenna, Rhombic antenna, Folded dipole & Yagi-Uda antenna, Corner reflector, Parabolic reflector antenna, Horn antenna Microstrip patch Antennas.

Antenna Measurements: Radiation pattern measurements, Measurement of gain, Polarization measurements.

Wave Propagation: Types of wave propagation, space wave propagation and line of sight distance for flat and curved surfaces.

Lab Components: Design and Simulation of some basic and practical antennas Using CST/HFSS.etc, Antenna Array Design Using EM Simulator and MATLAB, Design of various Feed Lines.

Learning Resources:

Text Books:

1. E.C. Jordan & K.G. Balmain, Electromagnetic waves & Radiating Systems, PHI, 2007
2. Constantine A. Balanis, Antenna Theory: Analysis and Design, John Wiley & Sons, 2009, 3rd Edition

Reference Books:

1. John D. Kraus, Antennas, McGraw Hill, 1988.
2. R.E. Collins, Antennas and Radio Propagation, Singapore: McGraw Hill, 1985.
3. R.S.Elliot, “Antenna Theory and Design”, IEEE Press, John Wiley, 2005. Recent edition.

Other suggested Readings:

1. https://nptel.ac.in/courses/108/105/108105114/
2. https://nptel.ac.in/courses/108/101/108101092/
3. https://nptel.ac.in/courses/117/107/117107035/

EC1304 **3-0-0 (3)**

Digital Communications

Pre-Requisites: EC1203, EC1303

Course Outcomes:

CO-1	Develop a digital communication system.
CO-2	Compute probability of error for Digital modulations
CO-3	Obtain the power spectra of digital modulated signals.
CO-4	Assign encoder and decoder schemes for error control.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	1	1	-	-	2	-	1	-	-	-	-	-	1	1
CO-2	2	3	-	-	1	2	1	-	-	-	-	-	1	1
CO-3	2	1	-	-	1	-	1	-	-	-	-	-	1	1
CO-4	2	3	-	-	-	1	-	-	-	-	-	-	1	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Analog communications versus digital communications, conversion of analog signal todigital form, Block diagram of digital communications, overview. Model of Digital Communication Systems, Gram-Schmidt Orthogonalization, Geometric interpretation of signals, detection of known signals in noise, probability of error, matched filter receiver, correlation receiver

Digital Modulation Techniques: Digital Modulation formats, Coherent binary modulation techniques (BPSK, BFSK), Coherent quadrature modulation techniques (QPSK), Non-Coherent binary modulation techniques (DPSK), QAM, M-ary modulation techniques (PSK, FSK, QAM), Comparison of M-ary digital modulation techniques, power spectra, bandwidth efficiency; BER for BPSK

Linear Block Codes: Introduction to error correcting codes, Matrix Description of Linear block Codes, The Parity Check Matrix , Decoding of linear block codes, syndrome decoding.

Cyclic Codes: Introduction to Cyclic codes, Polynomials, Algebraic description of Cyclic codes, The Division algorithm for polynomials, a method for generating cyclic codes, Matrix description of cyclic codes, Systematic and non-systematic encoding and parity check matrix.

Convolutional Codes: Introduction to Convolutional codes, Tree codes and Trellis codes.

Learning Resources:

Text Books:

1. Simon Haykin, Digital Communications, John Wiley & Sons, 2009.
2. B.Sklar, Digital Communications, Pearson Education, New Delhi, 2009, 2nd Edition.
3. John G.Proakis, Digital Communications, McGraw Hill, 2014, 5th Edition.

Reference Books:

1. Leon W.Couch, Digital and Analog Communication Systems, Pearson , Eighth edition,2013
2. Mrs. Pratibhad D.Kulkarni and Miss Sharvari D.Kulkarni, Analog and Digital Communication, Nirali Prakashan, Educational Publishers, 2019.

EC1306 **0-1-4 (3)**

Product Development

Pre-Requisites: **EC1102**

Course Outcomes:

CO-1	Express Product Design Ideas using 2D or 3D sketches
CO-2	Model the components with geometric (engineering) specifications and appropriate materials
CO-3	Develop a prototype of the product
CO-4	Evaluate the entire product and the product based on testing with user
CO-5	Explore the scope for protecting novelty of the product through patent

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	-	-	2	3	3	3	2	2	3	3	2	3	-	-
CO-2	-	-	2	3	3	3	2	2	3	3	2	3	-	-
CO-3	-	-	2	3	3	3	2	2	3	3	2	3	-	-
CO-4	-	-	2	3	3	3	2	2	3	3	2	3	-	-
CO-5	-	-	2	3	3	3	2	2	3	3	2	3	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Design Thinking process for Product Development: Review of five step design thinking process of Empathize- Define- Ideate- Prototype- Test.

Project Selection: Identification of the problem through empathy, formulate and ideate to solve the problem.

Product Development:
Sketching: 2D and 3D sketching: Students will sketch the concept on drawing sheets/ digital screens. The drawings will contain the specifications of the geometric form.
3D Modelling: Develop the 3D model features including free form surfaces, final product design specifications, parametric design.
Physical Component Development: Development of components: fabrication of actual components of the product using the materials and tools available in the lab, Iterations.

Iterative improvement of the product and Report writing: Development of assemblies/mock-up models/ working models/ prototypes/functional models/products, Testing and design review, Report writing.

IPR: Different forms of innovations emanating from the human mind and their protection using different tools of IPR, Basic introduction to Patents, Trademarks, Copyright, Industrial Designs Registrations, Geographical Indications Trade Secrets. Filing of IPR, implications, Ethics and societal implications of Intellectual Property Rights.

Learning Resources:

Textbooks:

1. Sullivan, Brian, The design studio method: creative problem solving with UX sketching, Focal Press, 2016.
2. Verma G.,Autodesk Fusion 360 Black Book, CADACAMCAE Works, 2021, 2nd edition.
3. Class Junghans and Adam Levy, “Intellectual Property Management: A guide for Scientists, Engineers, Financers and Managers”, Willey (2006)

Other Suggested Reading:

1. Self-Paced Tutorials: https://help.autodesk.com/view/fusion360/ENU/courses/
2. Product Documentation https://help.autodesk.com/view/fusion360/ENU/?guid=GUID1C665B4D-7BF7-4FDF-98B0-AA7EE12B5AC2

EC1382 **1-0-0 (0.5)**

Fractional Course - II

Pre-Requisites: None

Course Outcomes:

CO-1	Acquire an in-depth understanding of the specific topic covered in the course, which could range from a particular technology, method, or recent advancement in Electronics and Communication Engineering.
CO-2	Develop hands-on skills relevant to the course topic, such as using specific tools, software, or techniques.
CO-3	Apply learned concepts to solve focused and practical engineering problems related to the course content
CO-4	Understand the interdisciplinary aspects and applications of the course to solve real-world industrial problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	3	-	-	-	-	-	-	-	-	-	1	2
CO-2	-	-	-	2	2	3	3	-	-	-	-	-	3	3
CO-3	-	-	3	2	2	-	-	-	-	-	-	-	3	3
CO-4	-	-	-	-	-	-	-	-	1	3	-	2	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

This one-week course aims to bridge the gap between academic learning and industry application / latest research developments, providing students with a comprehensive understanding of the Electronics and Communication engineering field and enhancing their readiness for professional careers.

a. **Structure:** Lectures delivered by an expert from the Electronics and Communication Engineering Industry / R&D Organization / Academic Institution (SPARK Collaborators / Foreign Subject Experts in GIAN program / Adjunct Professors from Foreign Universities @ NITW).
b. **Content:** Topics covering current practices, case studies, technological advancements, and future trends.
c. **Interactive Sessions:** Q&A sessions, discussions, and case study analyses to foster interaction between students and the subject expert.
d. **Assessment:** the mode of assessment (Participation, a short reflective report / a presentation summarizing key takeaways from the lectures / Objective or descriptive type exam, etc.) will be decided by the subject expert

Learning Resources:

1. Course material and any learning resources suggested by the experts

EC1308 **0-1-2:(2)**

Electronic Measurements and Instrumentation Lab

Pre-Requisites: **None**

Course Outcomes:

CO-1	Measure displacement using capacitive and resistive transducers.
CO-2	Measure temperature and strain using appropriate transducers
CO-3	Build a simple data acquisition system
CO-4	Control DMM and DSO via GP-IB and perform measurements of sensor signals

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	1	-	-	1	-	-	-	2	-	-	-	2	2
CO-2	2	1	-	-	1	-	-	-	2	-	-	-	2	2
CO-3	-	2	2	2	2	-	-	-	2	-	-	1	2	2
CO-4	-	3	-	-	2	-	-	-	2	-	-	-	2	2

List of Experiments:

1. Calibration and Study of DMM, DSO, and AWG
2. Displacement measurement using resistive transducer (LDR) and LVDT
3. Strain and Force measurement using strain gauge
4. Velocity and acceleration measurement using accelerometer
5. Temperature measurement using Thermistor, thermocouple and RTD
6. Load measurement using Load cell.
7. Pressure Measurement and recording.
8. Introduction to Smart sensors and MEMS
9. Development of signal condition circuit and interfacing to read

EC1310 **0-1-2:(2)**

Analog and Digital Communications Lab

Pre-Requisites: **EC1303, EC1304**

Course Outcomes:

CO-1	Generate AM and FM signals and evaluate their performance
CO-2	Perform signal sampling by determining the sampling rates for baseband
CO-3	signals and reconstruct the signals
CO-4	Generate digital modulation signals for ASK, PSK and FSK and perform their Detection

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO-1	2	1	-	-	3	3	-	-	2	-	-	1	2	2
CO-2	3	1	-	-	3	-	-	-	2	-	-	1	2	2
CO-3	1	1	-	-	3	1	-	-	2	-	-	1	2	2
CO-4	2	1	-	-	3	2	-	-	1	-	-	1	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

List of Experiments:

1. DSBSC and AM Transmitter & the corresponding Receiver
2. FM Transmitter & Receiver
3. Analog signal sampling & Reconstruction
4. Frequency Division Multiplexing and Demultiplexing
5. Time Division Multiplexing and Demultiplexing
6. Generation & Detection of PAM/PWM/PPM
7. Generation & Detection of PCM
8. Generation & Detection of DM/SIGMA DELTA/ADM
9. Baseband digital data transmission
10. Generation & Detection of BPSK/DPSK/DEPSK
11. Simulation of digital modulation schemes

7th Semester

EC1401 **3-0-0 (3)**

Microwave and Lightwave Technologies

Pre-Requisites: **None**

Course Outcomes:

CO-1	Study the performance of specialized microwave tubes such as klystron, reflex klystron, magnetron and Travelling wave tube.
CO-2	Understand the operation of passive waveguide components.
CO-3	Analyze microwave circuits using scattering parameters.
CO-4	Identify and characterize different components of an optical fiber communication link
CO-5	Analyze optical source, Fiber and Detector operational parameters

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	1	2	-	-	-	-	-	-	-	-	-	-	2	-
CO-2	1	2	-	-	-	-	-	-	-	-	-	-	2	-
CO-3	2	3	-	-	-	-	2	-	-	-	-	-	2	2
CO-4	2	-	-	-	1	-	-	-	-	-	-	-	2	2
CO-5	1	-	2	2	2	1	-	-	-	-	-	-	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Introduction and applications of microwave engineering.

Microwave tubes: Structure and operation of Klystron amplifier and Reflex Klystron oscillator, and their applications.

Microwave Solid State Devices: structure and Operation of PIN Diode, Gunn Diode, Schottky Barrier Diode, IMPATT diodes, Varactor Diode, and their Applications.

Scattering Parameters its Properties: Scattering matrix of n-port microwave junctions. Tee Junctions, directional coupler, Magic tee, Faraday rotation, Circulators and isolators, Cavity resonators, Strip line & Micro stripline components.

Microwave measurements: Vector Network Analyzer (VNA), calibration of VNA, S-parameter, group delay and VSWR measurement of passive components. Microwave Power, impedance and gain measurements.

Optical fiber: Step index fiber, Graded index fiber, Fiber materials, and Attenuation mechanisms.

Optical sources and Photo-detectors: LED, LASER DIODES, PIN Photo-detector, Avalanche photodiode, Link power budget design.

Learning Resources:

Text Books:

1. R.E.Collin, Foundations for Microwave Engineering, Mc Graw Hill, 2011, 2nd Edition.
2. S.Y.Liao, Microwave Devices and Circuits, Prentice Hall of India, 2002, 4th Edition.
3. G. KEISER, Optical Fiber Communications, MGH, 2010, 4th Edition.

Reference Books:

1. G.P. Srivastava and V.L. Gupta, Microwave Devices and Circuit Design, PHI, 1st Edition
2. J. GOWER, Optical Communication Systems, PHI, 1993, 2nd Edition.
3. G.P. Agrawal, Fiber-optic communication systems, 2012, 4th Edition.

EC1403 **0-1-2 (2)**

Microwave and Lightwave Technologies Lab

Pre-Requisites: **EC1401**

Course Outcomes:

CO-1	Measure performance of simple microwave circuits and devices.
CO-2	Perform microwave measurements with sophisticated instruments such as vector network analyzer and spectrum analyzer
CO-3	Assess the performance of optical devices: light sources, fibers and detectors.
CO-4	Plot the loss characteristics of optical fibers.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	-	2	-	-	-	-	-	-	1	-	2	-	2	2
CO-2	1	2	-	-	-	-	-	-	1	-	2	-	2	2
CO-3	-	2	-	-	1	-	-	-	1	-	2	-	2	2
CO-4	1	2	-	-	-	-	-	-	1	-	2	-	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. Study of Microwave Test Benches.
2. Mode characteristics of Reflex Klystron.
3. Gunn oscillator characteristics and power measurement.
4. Measurement of VSWR & impedance.
5. Measurement of radiation pattern and gain of an antenna.
6. Properties of circulators & Directional coupler.
7. Properties of the Magic Tee Junction.
8. Vector Network Analyzer Demonstration.
9. Measurement of numerical aperture and length of the fiber.
10. Study of Optical Sources, Detectors Characteristics.

EC1489 **0-0-0 (2)**

Seminar and Technical Writing

Pre-Requisites: **None**

Course Outcomes:

CO-1	Consolidate ideas based on expert talks attended
CO-2	Prepare a well-organized report employing elements of critical thinking and technical writing
CO-3	Demonstrate the ability to describe, interpret and analyze the subject matter and develop competence in presenting

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2		2			3	3		2	3		3		
CO-2	2		2			3	3		2	3		3		
CO-3	2		2			3	3		2	3		3		

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

In Seminar and Technical Writing, every student is expected to prepare a well-organized report based on one / all of the following:

- by attending at least 5 expert lectures/ invited talks/ Seminar/ Popular lectures etc. organized by the institute/any of the departments, ideally in a specific domain or with the same theme.
- prepare a business or marketing plan based on patent search

The student is expected to consolidate the ideas from these lectures/patent searches and may even include material from other sources to strengthen the content of the report. The student should prepare a well-organized report based on the above and present it to the panel constituted by the department, for evaluation.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria.

Criteria	Description	Weightages
I	Clarity on the topic	
II	List of lectures attended	
III	Report	
IV	Presentation	
V	Response to questions	

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3
I	X		
II	X		
III		X	
IV			X
V			X

EC1495 **0-0-0 (2)**

Minor Project

Pre-Requisites: **None**

Course Outcomes:

CO-1	Apply engineering principles to real-world projects
CO-2	Plan and monitor project tasks individually or as a team
CO-3	Demonstrate practical experience in project execution
CO-4	Communicate project findings clearly through reports and presentations

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	3	3	3	-	-	-	2	1	-	3	-	-
CO-2	2	2	2	2	2	-	-	-	3	2	3	3	-	-
CO-3	2	2	2	2	2	-	-	-	3	2	3	3	-	-
CO-4	1	1	1	1	1	-	-	-	3	3	-	-	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Description:

Students are expected to choose real world or relevant problems and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel can decide the suitability and worthiness of the project

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria. Weightage for each criterion will be determined by the panel and will be informed to the students.

Criteria	Description	Weightages
I	Identification of Problem Domain	
II	Study of Existing Systems and establishing clear objectives	
III	Planning of project and work distribution within the team	
IV	Proper Documentation and Technical Writing	
V	Presentation and Response to questions	

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3	CO4
I	X			
II	X			
III		X	X	
IV				X
V				X

EC1491 **0-0-0 (2)**

Short-Term Industrial /EPICS /Research Experience

Pre-Requisites: **None**

Course Outcomes:

CO-1	Apply engineering principles to real-world problems, gaining practical experience
CO-2	Plan, manage and execute the work with ethical consideration
CO-3	Review the social and environmental impact of the work
CO-4	Communicate the learnings through report and presentation

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	3	3	3	-	-	-	-	-	-	3	-	-
CO-2	2	2	2	2	2	-	-	3	3	-	3	3	-	-
CO-3	-	-	-	-	-	3	3	-	-		-	3	-	-
CO-4	-	-	-	-	-	-	-	-	-	3	-	3	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Description:

Every student has to undergo either a Summer Internship / EPICS / Research project. The summer internship may be undergone in an Industry/Research organization or any premier academic Institution, including NIT Warangal for 6-8 weeks. The EPICS/research project shall be registered under the guidance of any faculty member in the institute. The student is required to submit a report and present the work before an evaluation committee, nominated by the Head of the Department.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria. Weightage for each criterion will be determined by the panel and will be informed to the students.

Criteria	Description	Weightages
I	Relevance of the area of work	
II	Performance of the Task	
III	Crucial learnings from the work	
IV	Report Preparation	
V	Presentation and Response to questions	

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3	CO4
I	X			
II		X		
III			X	
IV				X
V				X

8th Semester

EC1498 **0-0-0 (6)**

Major Project

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify a domain specific and contemporary topic
CO-2	Review literature to identify gaps and define objectives & scope of the work.
CO-3	Develop a prototype/model, experimental set-up or software systems to meet the objectives
CO-4	Analyze the results to draw valid conclusions

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	2			2	1		1	3	1	1	2		
CO-2	2	2			1	2	1	1	2	2		3		
CO-3	2	2	3	3	3	2	2	2	2	1	3	2		
CO-4	2	2		3	3				2	2		3		

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Description:

Students are expected to choose real-world contemporary problem and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel will decide the suitability and worthiness of the project

The B.Tech. Project work will be evaluated for 100 marks, with the following weightages:

Component	**Weightage**
Periodic evaluation by Guide	40 marks
Mid-term review	20 marks
End Semester viva-voce examination	40 marks
Total	100 marks

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria. Weightage for each criterion will be determined by the panel and will be informed to the students**.**

Criteria	**Description**	**Weightages**
I	Selection of topic	
II	Literature Survey	
III	Objectives and Solution Methodology	
IV	Performance of the Task and clarity on the work	
V	Report Preparation	
VI	Presentation and Response to questions	

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3	CO4
I	X			
II		X		
III		X		
IV			X	
V				X
VI				X

Refer to B.Tech. – Regulations for any further information regarding Mid-term review, End Sem evaluation, Template for report preparation and plagiarism.

Professional Elective - I

EC1321 **3-0-0 (3)**

CMOS VLSI Design

Pre-Requisites: **EC1104**

Course Outcomes:

CO-1	Understand the behaviour of the MOS Transistor and understand effects of scaling on the performance of MOS transistor.
CO-2	Design of CMOS inverter and analyses the impact of variation of design constrains on its performance metrics.
CO-3	Understand the various logic styles and design of combinational, sequential circuits using CMOS logic.
CO-4	Small signal behaviour of MOS transistors and design of single stage amplifiers with current source load.
CO-5	Various types of faults and DFT techniques.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	-	-	-	-	-	-	-	-	-	-	-	1	1
CO-2	-	3	2	-	-	-	-	-	-	-	-	-	1	1
CO-3	-	2	-	-	-	-	-	-	-	-	-	-	1	1
CO-4	-	3	-	-	-	-	-	-	-	-	-	1	1	1
CO-5	2	3	-	-	2	-	-	1	-	-	-	-	1	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Principles of CMOS IC fabrication: Introduction to IC technology, Fabrication process: nMOS, pMOS and CMOS Relationship, Sheet Resistance concept applied to MOS transistors and Inverters, Scaling models and scaling factors, Scaling factors for device parameters, Limitations of scaling.

MOS Transistor current voltage characteristics, body bias, small signal model including channel length modulation and body bias, Oxide and junction capacitances associated with MOSFET, MOSFET as capacitor, switch.

CMOS IC Digital building blocks CMOS logic, suitability of CMOS for digital IC design, Design of CMOS combinational building blocks for given propagation delay, power dissipation and noise margin, design of symmetric gates, techniques to drive large capacitive loads, efficient design approaches to optimize delay, pseudo NMOS logic, ratioed logic, pass transistor logic, transmission gates, CMOS sequential logic building blocks, dynamic logic circuits.

Analog IC building blocks: Significance of analog integrated circuits, Suitability of CMOS for analog IC design, biasing styles, single stage amplifier with resistive load, single stage amplifier with diode connected load, CS, CD, CG amplifiers, current sources and sinks, limitations of single stage amplifier

Learning Resources:

Text Books:

1. Jan M Rabaey, Digital Integrated Circuits, Pearson Education, 2003, 2nd Edition.
2. Sung-Mo Kang, CMOS Digital Integrated Circuits, McGraw-Hill, 2003, 3rd Edition.
3. Behad Razavi, Design of Analog CMOS Integrated Circuit, McGraw Hill Education, 2017, 2nd Edition.

Reference Books:

1. Neil H. E Weste, David Harris, Ayan Banerjee, CMOS VLSI Design – A Circuits and Systems Perspective, Pearson, 2009, 3rd Ed.
2. Wayne Wolf, Modern VLSI Design - Pearson Education, 2015, 4th Edition.

EC1323 **3-0-0 (3)**

Organic Electronics

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand —what is organic electronics?
CO-2	Understand the structure and properties of organic materials and devices
CO-3	Explain energy bands, charge transport, and doping in organic electronic materials.
CO-4	Exemplify the architecture, characterization, and utilization of electronic components based on organic electronic materials

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	1	3	–	–	–	2	–	–	–	2	3	3	2
CO-2	2	2	3	2	–	–	–	–	–	–	2	2	2	2
CO-3	3	2	3	2	3	–	–	–	–	–	1	2	2	2
CO-4	3	2	3	–	3	–	–	–	–	1	2	2	3	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Scope of Organic and molecular electronics

Material's Foundations: Electronic Structure, Chemical Bonding, Bonding in Organic Compounds, Crystalline and nanocrystalline materials, Polymers, Diffusion.

Electrical Conductivity: Classical Theory, Energy Bands in Solids, Organic Compounds, Low-frequency conductivity, Conductivity at high frequencies.

Optical Phenomena: Electromagnetic radiation, refractive index, Interaction of EM waves with Organic Molecules, Transmission and Reflection from Interfaces, Waveguiding, Surface Plasmons, Photonic Crystals.

Electroactive Organic Compounds: Selected Topics in Chemistry, Conductive Polymers, Charge-Transfer Complexes, Graphene, Fullerenes and Nanotubes, Piezoelectricity, Magnetic Materials.

Tools for Molecular Electronics; Liquid Crystals and Devices.

Plastic Electronics: Organic Diodes, MIS structures, Organic FETs, Transparent Conducting Films, Organic LEDs (OLEDs), Organic Photovoltaic Devices. Chemical Sensors and Physical Actuators; Molecular and Nanoscale Electronics; Bioelectronics.

Learning Resources:

Text Books:

1. Michael C. Petty, Organic and Molecular Electronics: From Principles to Practice, Wiley, 2018, 2nd Edition.

Reference Books:

1. Stephen R. Forrest, Organic Electronics: Foundations to Applications, Oxford University Press, 2020, 1st edition.
2. Piero Cosseddu and Mario Caironi, Organic Flexible Electronics: Fundamentals, Devices and Applications, Elsevier, 2021, 1st edition.

EC1325 **3-0-0: (3)**

Electronic Instrumentation

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand and estimate errors in a measurement system.
CO-2	Identify the instrument suitable for specific measurements.
CO-3	Estimate accurately the values of R, L and C employing suitable bridges.
CO-4	Understand the basic principles of transducers for displacement, velocity, temperature and pressure.
CO-5	Operate special measuring instruments such as Wave Analyzer, Harmonic Distortion Analyzer and Spectrum Analyzer.
CO-6	Identify data acquisition system for a specific application

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	-	-	-	-	-	-	-	-	-	-	-	2	-
CO-2	2	1	-	-	-	-	-	-	-	-	-	-	2	2
CO-3	1	2	2	-	-	-	-	-	-	-	-	-	2	2
CO-4	2	1	-	-	-	-	-	-	-	-	-	-	2	-
CO-5	2	2	-	-	-	-	-	-	-	-	-	1	2	2
CO-6	1	3	-	-	-	-	-	-	-	-	-	-	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Measurement and Error: Sensitivity, Resolution, Accuracy and Precision, Absolute andRelative types of errors, Statistical analysis, Probability of Limiting errors, Linearity.

Instruments: Current and Resistance in instruments, Analog and Digital Multimeters,Measurement of time and Frequency – Digital Frequency Meter and applications.

Impedance Measurement: Kelvin Bridge; Megger; Maxwell, Hay and Shering Bridges. Q-meter; Noise and Interference reduction techniques in Measurement Systems, Wave Analyzer, Spectrum Analyzer, FFT Analyzer, Oscilloscopes: Pulse Measurements, Delayed Time Base,Analog Storage, Sampling and Digital Storage Oscilloscopes.

Transducers: Classification and selection of Transducers, Introduction to Strain, Load, Force, Displacement, Velocity, Acceleration, Pressure and Temperature Measurements; Introduction to Smart sensors and MEMS.

Introduction to Data Acquisition Systems (DAS): Block Diagram, Specifications and various components of DAS, applications of DAS in various fields. General purpose Instrumentation Bus (GP-IB): Protocol, SCPI Commands and Applications to DSO and DMM

Learning Resources:

Text Books:

1. Oliver and Cage, Electronic Measurements and Instrumentation, by McGrawHill, 2017.
2. W.D.Cooper Felbrigg, Electronic Instrumentation & Measurement techniques, PHI,1990.

Reference Books:

1. D.A. Bell, Reston, Electronic Instrumentation and Measurements, 2013, 3rd Edition.
2. H S Kalsi, Electronic Instrumentation, McGraw Hill, 2017, 3rdEdition.

Professional Elective - II

EC1322 **3-0-0 (3)**

Introduction to Artificial Intelligence and Machine Learning

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the key concepts of Artificial intelligence
CO-2	Design and implement machine learning solutions to classification, regression, and clustering problems
CO-3	Understand and implement the Artificial Neural Networks
CO-4	Evaluate and interpret the results of the algorithms
CO-5	Analyze working of convolutional neural networks

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	–	2	–	–	2	–	–	–	2	–	2	2	2	–
CO-2	2	2	2	–	2	–	–	–	2	–	2	2	2	–
CO-3	–	2	–	–	2	–	–	–	2	–	2	2	2	–
CO-4	1	2	–	–	2	–	–	–	2	–	2	2	2	–
CO-5	1	2	–	–	2	–	–	–	2	–	2	2	2	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to AI: Introduction, history, intelligent systems, foundations of AI, applications, development of AI languages, current trends.

Supervised Machine Learning: Basics of linear regression, its assumptions, limitations and industry applications. Least square based and Gradient Descent Based Regression, Multiple linear regression, Polynomial regression, Logistic regression

Artificial Neural Networks: Biological neurons and artificial neurons. Model of an ANN. Activation functions used in ANNs. Typical classes of network architectures. Mathematical Foundations and Learning mechanisms, Feed forward ANN: Structures of Multi-layer feedforward networks. Back propagation algorithm. Back propagation – training and convergence. Functional approximation with back propagation. Introduction to PINNS.

Unsupervised Machine Learning: Different clustering methods (Distance, Density, Hierarchical) , Iterative distance-based clustering; K-Means Clustering Algorithm and Image Quantization, basics of Principal Component Analysis

Introduction to Deep learning: Analyze the key computations underlying deep learning, Convolutional Neural Network, Building blocks of CNN- Convolutional layers, pooling layers dense layers.

Learning Resources:

Text Books:

1. Christopher Bishop, Pattern Recognition and Machine Learning, Springer 2010.

Reference Books:

1. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshiran, Introduction to Statistical Learning, Springer, 2017.
2. Ian Goodfelllow, YoshuaBenjio, Aaron Courville, Deep Learning, The MIT Press,2016.
3. Richard O. Duda, Peter E. Hart, David G. Stork, Pattern Classification, John Wiley & Sons Inc. 2003, Second Edition.

EC1324 **3-0-0 (3)**

Embedded and Real Time operating systems

Pre-Requisites: **EC1202, MA1163**

Course Outcomes:

CO-1	Identify the applications, Design metrics and challenges of Embedded system
CO-2	Design, implement and test an embedded system.
CO-3	Write the programs for embedded system.
CO-4	Describe the various components and operating systems used in real-time
CO-5	Embedded systems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	-	2	-	-	-	-	-	-	-	-	_	1	2	2
CO-2	2	3	2	2	-	-	-	-	-	-	_	1	2	2
CO-3	2	3	-	2	-	-	-	-	-	-	_	1	2	2
CO-4	-	2	-	2	-	-	-	-	-	-	_	1	2	-
CO-5	-	2	2	-	-	-	-	-	-	-	_	1	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Embedded Systems: Embedded systems Overview, Embedded Systems Vs General Computing Systems, History of Embedded Systems, Classification, Major Application Areas, Purpose of Embedded Systems, Characteristics of embedded computing applications, Design Challenges, Common Design Metrics

Embedded System Development: Core of the Embedded System: General Purpose and Domain Specific Processors, ASICs, PLDs, Commercial Off the Shelf Components (COTS). Memory: ROM, RAM, Memory according to the type of Interface, Memory Shadowing, Memory selection for Embedded Systems, Sensors and Actuators, Reset Circuit, Brown-out Protection Circuit, Oscillator Unit, Real Time Clock, Watchdog Timer Communication Interface: Onboard and External Communication Interfaces

Embedded system Program: Embedded Firmware, ARM processor Architecture, pipeline, registers, instructions, thumb mode, exceptions Embedded Firmware Design Approaches and Development Languages.

Real-Time Operating Systems: Architecture of the kernel, Tasks and Task Scheduler, Scheduling algorithms, Interrupt Service Routines, Semaphores, Mutex, Mailboxes, Message queues, Event Registers,

Pipes, Signals, Timers, Memory management, Priority Inversion problem. Overview of off-the shelf operating systems-Micro C/OS II, Vxworks, RT Linux.

Overview of Hardware – Software co design: Fundamental Issues in Hardware-Software co-design, Computation models in Embedded system design, Introduction to Unified Modeling Language (UML), Hardware Software Trade-offs

Learning Resources:

Text Books:

1. Shibu K.V, Introduction to Embedded Systems, McGrawHill.
2. Santanu Chattopadhya, Embedded Systems Design, PHI, 2013, 2nd Edition.
3. Frank Vahid, Tony Givargis, John, Embedded System Design, Wiley
4. K.V.K.K. Prasad, Embedded/Real-Time Systems: Concepts Design and Programming Dreamtech,2005.

Reference Books:

1. Lyla , Embedded Systems, Pearson,2013
2. David E. Simon, An Embedded Software Primer, Pearson Education,2002.

EC1326 **3-0-0 (3)**

Web Technologies

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand, analyze and build dynamic and interactive web sites
CO-2	Install and manage server software and server-side tools.
CO-3	Understand current and evolving Web languages for integrating media and user interaction in both front end and back end elements of a Web site.
CO-4	Analysis and reporting of web data using web analytics
CO-5	Applying different testing and debugging techniques and analyzing the web site Effectiveness.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	3	3	3	1	2	1	2	1	–	–	–	2	–
CO-2	–	2	2	2	1	1	2	–	–	–	–	–	2	2
CO-3	2	2	2	1	1	1	–	1	1	–	–	–	2	2
CO-4	–	1	1	2	3	1	1	1	1	–	–	–	2	2
CO-5	2	2	2	2	1	1	–	–	1	–	–	–	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Basic design and implementation of websites: Protocols and Programs, Secure Connections, Applications and Development Tools, The Web Browser, Discussion of different navigation and organizational strategies.

Client-side technologies: Introduction, The Development Process, Basic HTML, Formatting and Fonts, Commenting Code, Hyperlinks, Simple HTML Forms, Web Site Structure, HTML5, CSS, JavaScript, JSON, and JQuery.

Server-side technologies: Definition, Choices, setting up, unix and Linux Web Servers, Which OS, Logging Users, Dynamic IPs, Starting to Script with PHP, Variables, Getting Some Input, Looping, Arrays, Functions, Browser Control, Browser Detection, String Manipulation with PHP, Files, Passwords, Email, Uploading.

Network and web security: Introduction to ethical hacking, Types of Attack and Intrusion, Firewalls, Passwords, Defense, Databases.

Learning Resources:

Text Books:

1. Ralph Moseley and M. T. Savaliya, Developing Web Applications, Wiley-India
2. Deitel, Deitel and Nieto, Internet and Worldwide Web - How to Program, PHI, 2011, Fifth Edition.
3. Bai and Ekedhi, The Web Warrior Guide to Web Programming, Thomson, 2008, Third Edition.

Reference Books:

1. Lemay Laura, Rafe Colburn, Jennifer Kyrnin, Mastering HTML, CSS & JavaScript Web, BPB Publication, 2016.
2. Vishvajeet. Sisodia, Basic of Web Design, HTML, CSS3, Centrum Press, 2014.

Other suggested Readings:

1. https://onlinecourses.swayam2.ac.in/nou24_cs09/preview

EC2322 **3-0-0 (3)**

Low Power VLSI

Pre-Requisites: **EC1321**

Course Outcomes:

CO-1	Identify clearly the sources of power consumption in a given VLSI Circuit.
CO-2	Design low power arithmetic circuits and systems.
CO-3	Choose the types of SRAMs/ DRAMs for the given Low power applications.
CO-4	Decide at which level of abstraction is advantageous to implement low power techniques in a VLSI system design.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	1	1	-	1	1	-	-	-	-	-	--	-	2	2
CO-2	-	-	-	3	-	-	-	-	-	-	-	-	2	2
CO-3	-	2	-	2	3	-	-	-	-	-	-	1	2	2
CO-4	-	-	-	1	-	-	-	-	-	-	-	-	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Sources of Power Dissipation, Static Power Dissipation, Active Power Dissipation, Circuit Techniques for Leakage Power Reduction

Adders: Standard Adder Cells, CMOS Adders Architectures, Low Voltage Low Power Design Techniques, Current Mode Adders

Multipliers: Types of Multiplier Architectures; Braun, Booth Multipliers and their performance comparison, Low Voltage Low Power Design Techniques

Memories: Sources of power dissipation in SRAMs, Low power SRAM circuit techniques, Sources of power dissipation in DRAMs, Low power DRAM circuit techniques

Wires: Increased delays of wires, new materials for wires and dielectrics, Basic background on testing, Low power and safely operating circuits, Case study – A Low power subsystem design

Learning Resources:

Text Books **:**

1. Kiat Seng Yeo and Kaushik Roy, Low- Voltage, Low-Power VLSI Subsystems, Tata Mc GrawHill, Edition 2009.
2. Soudris D, Piguet C and Goutis C, Designing CMOS Circuits for Low Power, Kluwer Academic Publishers,2002.

Reference Books:

1. Jan Rabaey, Low Power Design Essentials, Springer,2009.

Professional Elective - III

EC1328 **3-0-0 (3)**

Internet of Things

Prerequisites: **None**

Course Outcomes:

CO-1	Understand IOT design requirements
CO-2	Compare various technologies and protocols
CO-3	Study OSI model and different protocols at each layer
CO-4	Study of IoT cloud platforms and using for various Application s
CO-5	Design and implement prototype for IoT end devices for various applications

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	-	1	-	2	-	-	-	-	-	-	1	2	2
CO-2	-	3	1	-	1	-	-	-	-	-	-	1	2	2
CO-3	-	-	1	-	1	-	-	3	-	-	-	1	2	2
CO-4	-	-	1	-	1	-	-	3	-	-	-	1	2	2
CO-5	-	-	3	-	1	-	3	-	-	-	-	1	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to IOT: The Technology of the Internet of Things, Applications of IoT, IoT Stack, Communication Strategies, Cloud platforms for IoT.

Internet Principles: Internet Communications: An Overview, OSI Model, IP, TCP. The IP Protocol Suite (TCP/IP), UDP, IP Addresses, DNS, Static IP Address Assignment, Dynamic IP Address Assignment, IPv6.

IoT Communication Protocols: Cellular, Satellite, Wi-Fi, Radio Frequency (RF), Bluetooth, RFID, NFC, LoRa.

Prototyping: Costs versus Ease of Prototyping, Prototypes and Production,
Changing Embedded Platform, Physical Prototype- Electronics, Sensors, Actuators,
Embedded Computing Basics-Microcontrollers, IoT platforms-, ESP8266, ESP32, Raspberry Pi.

Serial Communication Protocols: SSI, SPI, I 2 C, UART

Cloud Platforms for IoT: Virtualization concepts and Cloud Architecture, Cloud services - SaaS, PaaS, IaaS, Study of IOT Cloud platforms - Thing Speak API, Amazon Web Services (AWS), Microsoft Azure IoT, Google IoT, IBM Watson IoT

Application Layer Protocols: Message Queuing Telemetry Transport (MQTT), Constrained Application Protocol (CoAP), Advanced Message Queuing Protocol (AMQP).

IoT Edge computing: Edge Computing Architectures, IoT edge computing capabilities.

Applications: Smart Buildings, Smart health, Home automation, Vehicle Fleet Management, Agriculture.

Prototype Development: Implementing an IoT end device for various societal problems

Learning Resources:

Text Books

1. Adrian McEwen, Hakim Cassimally, Designing the Internet of Things, Wiley 2013.
2. Naveen Balani, Enterprise IoT Create Space Independent Publishing Platform 2016.

Reference Books:

1. Nayan B. Ruparelia, “Cloud Computing”, MIT Press 2016.

EC1330 **3-0-0 (3)**

Cellular and Mobile Communications

Pre-Requisites: **EC1303, EC1304**

Course Outcomes:

CO-1	Understand the evolution of cellular communication systems up to and beyond 3G
CO-2	Design a cellular link and estimate the power budget.
CO-3	Choose proper multiple accessing methods depending on channel model
CO-4	Identify traffic channels for call processing
CO-5	Calculate key performance metrics of a cellular communication system.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	-	-	-	-	1	2	2	-	-	-	-	-	2	-
CO-2	2	-	-	-	2	2	1	-	-	-	-	2	2	2
CO-3	2	-	-	-	2	2	1	-	-	-	-	-	2	2
CO-4	1	-	-	-	2	-	2	-	-	-	-	-	2	2
CO-5	2	-	-	-	3	2	2	-	-	-	-	2	2	2

Syllabus:

An Overview of Wireless Systems: Introduction wireless communication

Cellular System design concepts and fundamentals: Frequency Reuse – Channel Assignment - Handoff Strategies – Interference and System Capacity – Improving Coverage and Capacity in cellular systems.

Mobile Radio Wave propagation – I: Large scale path loss and propagation models – Reflection – Diffraction – Scattering – Practical link budget design – Outdoor propagation models – Indoor propagation models.

Mobile Radio Wave propagation – II: Small- Scale fading and multipath propagation, Rayleigh and Rician Distributions. Multiple Access Techniques for Wireless Communications -I – FDMA – TDMA –Spread Spectrum multiple access;

1st & 2nd Generation cellular Systems: AMPS; GSM features – Architecture – Radio subsystems – Traffic channels – call processing.

3rd & 4th Generation cellular Systems: CDMA features – Architecture – Forward and reverse channels – power control - system capacity; OFDM; 4G LTE systems

Learning Resources:

Text Books:

1. William C Y Lee, Mobile Cellular Telecommunications, McGraw Hill (Main Book),2020, 2nd edition
2. Stallings, Wireless Communications and Networks, Prentice Hall, 2004, 2nd edition

Reference Books:

1. Schwartz, Mobile Wireless Communications, Cambridge University Press (Main Book),2004.
2. Theodore S Rappaport, Wireless Communications Principles and Practice, Prentice Hall, 2001, 2nd edition.

EC2302 **3-0-0 (3)**

Verification and Testing

Pre-Requisites: **EC1321**

Course Outcomes:

CO-1	Apply scheduling and allocation algorithms for VLSI verification
CO-2	Develop logic optimization for sequential circuits
CO-3	Construct binary decision diagram and apply temporal logic
CO-4	Discuss about built in self-test and its application in modern digital design
CO-5	Use modern tools for testing and verification

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	1	2	2	2	1	–	–	–	–	–	–	–	–	–
CO-2	1	3	1	2	2	–	–	–	–	–	–	–	–	–
CO-3	2	2	1	2	2	–	–	–	–	–	–	–	–	–
CO-4	1	1	1	1	2	2	–	–	–	–	–	–	–	–
CO-5	1	1	1	2	2	2	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Introduction to Digital VLSI Design Flow, High Level Design Representation, Transformations for High Level Synthesis.

Scheduling and Allocation: Scheduling, Allocation and Binding Problem, Scheduling Algorithms, Binding and Allocation Algorithms, Allocation Techniques: Clique Partitioning, Left-Edge Algorithm, Iterative Refinement.

Logic Optimization and Synthesis: Two level Boolean Logic Synthesis, Heuristic Minimization of Two-Level, Finite State Machine Synthesis, Multilevel Implementation.

Binary Decision Diagram: Introduction and construction, Ordered Binary Decision Diagram, Operations on Ordered Binary Decision Diagram, Ordered Binary Decision Diagram for Sequential Circuits.

Temporal Logic: Introduction and Basic Operations on Temporal Logic, Syntax and Semantics of CLT, Equivalence between CTL Formulas

Model Checking: Verification Techniques, Model Checking Algorithm, Symbolic Model Checking

Introduction to Digital Testing: Introduction to Digital VLSI Testing, Functional and Fault Simulation and Testability Measures

Fault Simulation: Testability Measures (SCOAP)Structural Testing, Fault Equivalence.

Combinational Circuit Test Pattern Generation: Introduction to Automatic Test Pattern Generation (ATPG) and ATPG Algebras, D-Algorithm

Sequential Circuit Testing and Scan Chains: ATPG for Synchronous Sequential Circuits, Scan Chain based Sequential Circuit Testing

Built in Self-test (BIST): Built in Self-Test, Memory Testing

Learning Resources:

Text Books:

1. M. L. Bushnell and V. D. Agrawal, Essentials of Electronic Testing, 3rd Kluwer Academic Publishers, 2002.
2. S. Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Prentice Hall, 2003, 2nd edition.
3. G. De Micheli. Synthesis and optimization of digital circuits, 1994, 1st edition.

Reference Books:

1. M. Huth and M. Ryan, Logic in Computer Science modeling and reasoning about systems, Cambridge University Press, 2004, 2nd Edition.
2. D. D. Gajski, N. D. Dutt, A.C.-H. Wu and S.Y.-L. Lin, High-Level Synthesis: Introduction to Chip and System Design, Springer, 1992, 1stEdition.

Other Suggested Readings:

1. NPTEL Courses (https://nptel.ac.in/courses/106103016).

EE1262 **3-0-0 (3)**

Control Systems Engineering

Pre-Requisites: **MA1161, MA1162**

Course Outcomes:

CO-1	Analyze electromechanical systems using mathematical modelling.
CO-2	Determine Transient and Steady State behavior of systems using standard test signals.
CO-3	Analyze linear and non-linear systems for steady state errors, absolute stability and relative stability.
CO-4	Design a stable control system satisfying requirements of stability and reduced steady state error.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	2	1	1	2	_	_	_	2	_	1	1	1	1
CO-2	3	2	1	2	1	_	_	_	2	_	1	1	1	1
CO-3	3	2	1	1	1	_	_	_	2	_	1	1	1	1
CO-4	2	3	2	1	1	_	_	_	2	_	1	1	1	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Concepts of Control Systems- Open Loop and closed loop control systems and their differences- Different examples of control systems- Classification of control systems, Feed-Back Characteristics, Effects of feedback. Mathematical models – Differential equations, Impulse Response and transfer functions.

Transfer Function Representation: Block diagram representation of systems considering electrical systems as examples -Block diagram algebra – Representation by Signal flow graph - Reduction using mason's gain formula.

Time Response Analysis: Standard test signals - Time response of first order systems – Characteristic Equation of Feedback control systems, Transient response of second order systems - Time domain specifications – Steady state response - Steady state errors and error constants – Effects of proportional derivative, proportional integral systems.

Stability Analysis in S-Domain: The concept of stability – Routh's stability criterion – qualitative stability and conditional stability – limitations of Routh's stability.

Root Locus Technique: The root locus concept - construction of root loci-effects of adding poles and zeros to G(s) H(s) on the root loci.

Frequency Response Analysis: Introduction, Frequency domain specifications-Bode Diagrams-Determination of Frequency domain specifications and Phase margin and Gain Margin-Stability Analysis from Bode Plots. Polar Plots, Nyquist Plots Stability Analysis. Compensation techniques – Lag, Lead, and Lead-Lag Controllers design in frequency Domain, PID Controllers.

State Space Analysis of Continuous Systems: Concepts of state, state variables and state model, derivation of state models from block diagrams, Diagonalization- Solving the Time invariant state Equations- State Transition Matrix and it's Properties – Concepts of Controllability and Observability.

Learning Resources:

Text Books:

1. Norman S. Nise, Control Systems Engineering, Willey Publications, 2019, 7th Edition.
2. I.J.Nagrath, M.Gopal, Control Systems Engineering, New Age Pub. Co, 2017, 6th Edition.
3. Katsuhiko Ogata, Modern Control Engineering, Pearson Education India, 2015, 5th Edition.

Reference Books:

1. G. Franklin, J. Powell, A. Emami-Naeini, Feedback control of dynamic systems, 2018, 8th Edition.
2. Richard C. Dorf, Robert H. Bishop, Modern Control Systems, Prentice Hall, 2015, 13th Edition.
3. B.C.Kuo, Automatic Control Systems, Wiley, 2014, 9th Edition.

Other suggested Readings:

1. https://www.controleng.com/
2. https://nptel.ac.in/courses/108/102/108102043/

Professional Elective - IV

EC1421 **3-0-0 (3)**

Digital Image Processing and Computer Vision

Pre-Requisites: **EC1203, EC1305**

Course Outcomes:

CO-1	Development of algorithms and techniques to analyze and interpret the visibleworld.
CO-2	Apply feature extraction and segmentation methods for computer processing.
CO-3	Implement pattern recognition algorithms for real world problems
CO-4	Design of detection and recognition algorithms for various computer vision like face/biometric etc. problems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	3	-	3	2	-	-	1	-	-	-	-	2	2
CO-2	3	3	3	2	2	2	-	2	-	-	-	-	2	2
CO-3	3	3	3	3	3	-	-	-	2	-	-	-	2	2
CO-4	2	3	2	2	2	2	-	2	2	-	-	-	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Digital Image Formation and Low-level processing: Overview and State-of-the-art, Fundamentals of Image Formation, Types of Image processing, Transformation: Orthogonal, Euclidean, Affine, Projective, etc; Image Transform like DFT, DCT etc., face/biometric etc. Convolution and Image Filtering, Image Enhancement and Various Techniques, Image Restoration and various techniques, Histogram Processing and Morphological Operations and its types.

Feature Extraction: Edges - Canny, LOG, DOG; Line detectors (Hough Transform), Corners- Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space Analysis- Image Pyramids and Gaussian derivative, Gabor Filters and DWT.

Image Segmentation: Region Growing, Edge Based approaches to segmentation, Graph- Cut, Mean-Shift, MRFs, Texture Segmentation; Object detection.

S-Pattern Analysis: Clustering: K-Means, K-Medoids, Mixture of Gaussians, Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised; Classifiers: Bayes, KNN.

Motion Analysis: Background Subtraction and Modeling, Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation.

Use Cases on Finger print recognition, Face detection and recognition, Object tracking, medical Diagnosis etc

Learning Resources:

Text Books:

1. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London Limited 2011.
2. D. A. Forsyth, J. Ponce, Computer Vision: A Modern Approach, PHI Learning 2009.
3. R.C. Gonzalez and R.E. Woods, Digital Image Processing, Pearson Education, ,2017, 4th Edition.
4. Jayaraman, S., Esakkirajan, S. and Veerakumar, T.,Digital image processing (Vol. 7014). New Delhi: Tata McGraw Hill Education, 2009.

Reference Books:

1. Milan Soanka, Vaclav Hlavac and Roger Boyle, Digital Image Processing and Computer Vision, Cengage Learning, 2014.

Other suggested Readings:

1. https://nptel.ac.in/courses/108/103/108103174/
2. https://nptel.ac.in/courses/106/106/106106224/
3. https://nptel.ac.in/courses/106/105/106105216/

EC1423 **3-0-0 (3)**

Hardware and Software Co-design

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand Hardware/Software Co-design
CO-2	Model the data flow and implement the same through software and hardware.
CO-3	Design the Control Flow on Transistor Structures
CO-4	Understand the design principles in SoC Architecture
CO-5	Design CORDIC and Crypto coprocessor.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	_	1	1		2		2			1		1	2	
CO-2	_	1	2		2	1	2					2	2	
CO-3	_	1	3		2		3			1		1	2	
CO-4	_	1	1		2	1	2					2	2	
CO-5	_	1	3		2		1			1		2	2	

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

The Nature of Hardware and Software: Introducing Hardware/ Software Co-design, The Quest for Energy Efficiency, The Driving Factors in Hardware/ Software Co-design, The Dualism of Hardware Design and Software Design.

Data Flow Modeling and Transformation: Introducing Data Flow Graphs, Analyzing Synchronous Data Flow Graphs, Control Flow Modeling and the Limitations of Data Flow, Transformations.

Data Flow Implementation in Software and Hardware: Software Implementation of Data Flow, Hardware Implementation of Data Flow, Hardware/ Software Implementation of Data Flow.

Analysis of Control Flow and Data Flow: Data and Control Edges of a C Program, Implementing Data and Control Edges, Construction of the Control Flow Graph and Data Flow Graph.

Finite State Machine with Data path: Cycle-Based Bit-Parallel Hardware, Hardware Modules, Finite State Machines with Datapath, FSMD Design Example: A Median Processor.

System on Chip: The System-on-Chip Concept, Four Design Principles in SoC Architecture, SoC Modeling in GEZEL. Applications: Trivium Crypto-Coprocessor, CORDIC Co-Processor.

Learning Resources:

Text Books:

1. Patrick Schaumont, A Practical Introduction to Hardware/ Software Co-design, Springer, 2010.
2. Ralf Niemann, Hardware/Software Co-Design for Data flow Dominated Embedded Systems, Springer, 1998.

Reference Books:

1. Soonhoi Ha, Jürgen Teich, Handbook of Hardware/Software Codesign (Springer Reference) 2017, ISBN: 978-94-017-7267-9.
2. Jørgen Staunstrup , Hardware/Software Co-Design: Principles and Practice, Wayne Wolf, 1997.

Other suggested Readings:

1. https://nptel.ac.in/courses/106/103/106103182/

EC1425 **3-0-0 (3)**

Satellite Communications

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the orbital and functional principles of satellite communication systems
CO-2	Architect, interpret, and select appropriate technologies for implementation of specified satellite communication systems
CO-3	Analyze and evaluate a satellite link and suggest enhancements to improve the link performance.
CO-4	Select an appropriate modulation, multiplexing, coding and multiple access schemes for a given satellite communication link.
CO-5	Specify, design, prototype and test analog and digital satellite communication systems as per given specifications.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	2	-	2	1	2	1	-	-	-	-	-	2	2
CO-2	1	-	-	1	2	2	2	-	-	-	-	-	2	2
CO-3	-	-	-	-	2	2	1	-	-	-	-	-	2	2
CO-4	1	-	-	-	3	2	1	-	-	-	-	1	2	2
CO-5	1	1	-	-	3	2	1	-	-	-	-	1	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Overview of Satellite Communications, GEO, MEO and LEO satellite systems, frequency bands

Orbital Mechanics: Orbit Equations, Locating the satellite w.r.t. the earth, Orbital elements, look Angles, Orbital perturbation, Effects of earth's oblateness, moon and sun, Satellite eclipse, sun transit outage, Coverage angle, slant range, satellite launching

Satellite subsystems: Attitude and Orbit Control System (AOCS), Telemetry, Tracking and Command System (TT&C), Power System, Satellite antennas, Communications subsystem, transponders

Satellite Link Design: Basic transmission theory, System noise temperature and G/T ratio, CNR, CIR, ACI, IMI, down link design, up link design, System design examples

Multiple Access Schemes: FDM/FM/FDMA, TDMA, Frame structure, frame acquisition, synchronization, TDMA in VSAT network, On-board processing, CDMA, Spread spectrum transmission and reception, DS-SS CDMA capacity,

VSAT Systems: Overview of VSAT systems, Network architectures, Access control, multiple access selection

LEO Satellite systems: Orbits, Coverage and frequency bands, off axis scanning, delay and throughput, NGSO constellation design, Problems, Earth station technologies.

Learning Resources:

Text Books:

1. Timothy Pratt, Charles Bostian Jermey Allnutt, Satellite Communications, John Wiley, Singapore, reprint 2013, Second Edition.
2. M. Richharaia, Satellite Communication Systems, BS Publishers, 2008, Second Edition.
3. Tri.T. Ha, Digital Satellite Communications, McGraw-Hill, 2000.

Reference Books:

1. Dennis Roddy , Satellite Communications, McGraw Hill,1996, 2nd Edition,.
2. K. N Raja Rao, Fundamental of Satellite Communications, PHI, 2004
3. Wilbur L. Pritchand, Robert A Nelson and Henri G.Suyderhoud , Satellite Communication Engineering, Pearson Publications, 2007, 2nd Edition,
4. Bruce R. Elbert, “The Satellite Communication Applications”, Hand Book, Artech House Bostan London, 1997.

EC2423 **3-0-0 (3)**

Electronics System Packaging

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the role of packaging in the computer, telecommunication, automotive, medical and consumer electronics industry
CO-2	Learn the fundamentals of electrical packaging design, design for reliability, thermal management
CO-3	Analyze the performance of various TSVs for 3-D ICs
CO-4	Identify the packaging materials with their appropriate properties

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	1	3	–	–	2	2	–	–	–	1	2	2	–
CO-2	3	3	3	2	–	2	1	–	–	–	1	2	2	–
CO-3	3	3	3	3	–	–	–	–	–	–	1	2	2	1
CO-4	3	3	3	3	–	2	1	–	–	–	1	2	2	1

Syllabus:

Overview of electronic systems packaging: Definition of a system and history of semiconductors, Products and levels of packaging, Packaging aspects of handheld products.

Overview of Semiconductor Packaging: Basics of Semiconductor and Process flowchart, Wafer fabrication, inspection and testing, Wafer packaging; Packaging evolution; Different integration approaches in SIP: TSV and Non-TSV. System-on-Package Technology, Chip connection choices, Wire bonding, TAB and flipchip.

Semiconductor Packages: Single chip packages or modules (SCM); Commonly used packages, advanced packages; Materials in packages; Thermal mismatch in packages; Current trends in packaging. Multichip modules (MCM)-types; System-in-package (SIP); Packaging roadmaps; Hybrid circuits.

Electrical Design considerations in systems packaging: Electrical Issues: Resistive, Capacitive and Inductive Parasitic, Layout guidelines and the Reflection problem; Interconnection. CAD for Printed Wiring Boards (PWB), PWB Technologies, Surface Mount Technology, Thermal design consideration in systems packaging, Embedded Passives Technology

3-D technology and Packaging Techniques: Silicon interposer technology, Through Silicon Vias (TSVs). Hybrid packaging technique, Silicon-Less Interconnect technology. 3D Integrated Architectures. Electrical Modeling of Through Silicon Via: Materials, Electrical Performance and Signal Integrity. Power distribution, Return path discontinuities and thermal management. Modeling and performance analysis

of Copper-based, CNT-based, GNR-based TSVs. Liners in TSVs. Physical Design and Thermal Management Techniques for 3-D ICs

Case study: Clock distribution networks for 3-D ICs

Learning Resources:

Text Books:

1. Rao R. Tummala, Fundamentals of Microsystem Packaging, McGraw Hill, 2001.
2. Rao R. Tummala, Introduction to System-on-Package (SOP): Miniaturization of the Entire System, McGraw Hill, 2008.
3. Madhavan Swaminathan and Ki Jin Han, Design and modeling for 3D ICs and Interposers World Scientific, 2014.
4. Vasilis F Pavlidis, E G Friedman, Three-Dimensional Integrated Circuit Design, Morgan Kaufmann Publishers, Elsevier, 2009.

Reference Books:

1. William D. Brown, Advanced Electronic Packaging, IEEE Press, 2006, 2nd Edition.

Other suggested Readings:

1. https://nptel.ac.in/courses/108/108/108108031/
2. https://nptel.ac.in/courses/112/105/112105267/

Professional Elective - V

EC1427 **3-0-0 (3)**

Computer Architecture and Organization

Pre-Requisites: **None**

Course Outcomes:

CO-1	Comprehend the components of a computer system.
CO-2	Understand the information flow in different processor architectures.
CO-3	Learn the concept of memory and memory and its application in computer.
CO-4	Study the I/O data transfer mechanisms and interrupt structures.
CO-5	Realize instruction level parallelism in multiprocessor system.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	–	2	–	–	1	–	–	–	–	–	–	–	1	1
CO-2	–	2	3	–	–	–	–	–	–	–	–	–	1	–
CO-3	2	3	–	–	–	–	–	–	–	–	–	–	1	–
CO-4	1	2	–	–	1	–	–	–	–	–	–	–	1	–
CO-5	–	2	1	3	–	–	–	–	–	–	–	2	1	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Overview of computer organization: Components and system buses; concepts of assembly and machine language programs; machine language program execution; instruction cycles; machine cycles and bus cycles.

CPU organization: Components and subsystems; register banks; internal bus structure; information flow; Instruction set – characteristics and functions; types of operation and operands; addressing modes – various ways of addressing memory and their timing characteristics; CISC and RISC architectures – examples; ALU – flags; logical operations; fixed point number representations and arithmetic; floating point number representations and arithmetic.

Control Unit: its operation; hardwired control unit; concepts of microprograms and microprogrammed control unit.

Memory organization: Memory hierarchy; main memory – types and interfacing; cache memory – its organizations and operations; levels of caches; memory management module – paging and segmentation; virtual memory.

I/O and interrupts: I/O interfacing and modes of I/O data transfer; Direct memory access – DMA controller; Interrupts and interrupt structures – interrupt cycles; programmable interrupt controllers.

Recent trends in computer system: Instruction level parallelism – instruction pipelining; pipeline hazards; concepts of multiprocessor systems; vector computation.

Learning Resources:

Text Books:

1. William Stallings, Computer Organization and Architecture – Designing for Performance, Pearson, 2010, 8th Edition.
2. J. P. Hayes, Computer Architecture and Organization, McGraw-Hill, 2012, 3rd Edition.

Reference Books:

1. V. Carl Hamacher, Computer Organization, McGraw Hill, 2011, 6th Edition.
2. J. L, Hennessy and D. A. Patterson, Computer Architecture – A Quantitative Approach, Morgan Kaufmann, 2012, 5th Edition.

EC1429 **3-0-0 (3)**

Cryptography and Network Security

Pre-Requisites: **None**

Course Outcomes:

CO-1	Analyze encryption algorithms.
CO-2	Apply cryptographic algorithms to build secure protocols
CO-3	Identify system vulnerabilities of communication protocols
CO-4	Design of secure protocols to solve real world scenario

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	1	-	1	-	2	-	-	-	-	-	-	-	1	1
CO-2	2	2	-	3	3	1	-	-	-	-	-	-	1	1
CO-3	-	-	3	1	1	2	-	-	-	-	-	-	1	1
CO-4	3	1	2	3	3	3	-	-	-	-	-	-	1	1
CO-5	1	-	1	-	2	-	-	-	-	-	-	-	1	1

1 – Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Security Goals and Services: Definitions – Threat; Vulnerabilities; Attacks – Classifications of attacks; Security services; Security mechanisms.

Cryptographic algorithms: Private key algorithms – Classical Encryption techniques; Stream ciphers; Block cipher modes; DES; AES; Random number generators; Public key algorithms - Principles of Public key Cryptography; RSA; Deffie-Hellman; ElGamal; Elliptic Curve Cryptography.

Security mechanisms: Key management and Distribution - Certificate authorities; PKI; MAC; Hashing; Digital Signatures-Authentication protocols; Digital Signature Standard;

Introduction to Network Security: Network security threats; Vulnerabilities - Denial-of- service/Distributed denial-of-service attacks; Spoofing, Man-in-the-middle, Replay, TCP/Hijacking, Fragmentation attacks, Weak keys, Port scanning, Dumpster diving, Birthday attacks, Password guessing, Eavesdropping, War driving, TCP sequence number attacks.

Network Defense Tools: Firewalls- Firewall Properties; Design of firewalls; VPN's; Filtering; Intrusion detection.

Security protocols: Network and transport layer security- SSL/TLS, IPsec IKE; IPsec AH, ESP; Application security- Kerberos; S/MIME; PGP.

Learning Resources:

Text Books:

1. Charlie Kaufman, Radia Perlman, Mike Speciner, Network Security: Private Communication in a Public World, Prentice Hall, 2002.
2. William Stallings, Cryptography and Network Security, Pearson Education, 2014, 6th Edition.

Reference Books:

1. P. Van Oorschot, S. Vanstone, Handbook of Applied Cryptography, CRC Press, 2004.

EC2427 **3-0-0 (3)**

Introduction to ASIC Design

Pre-Requisites: **EC1202**

Course Outcomes:

CO-1	Architect ASIC library design.
CO-2	Develop programmable ASIC logic cells.
CO-3	Design I/O cells and interconnects.
CO-4	Identification of new developments in SOC and low power design.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	1	-	2	1	2	–	–	–	–	–	–	–	–	–
CO-2	2	2	3	2	3	–	–	–	–	–	–	–	1	–
CO-3	3	3	3	3	3	–	–	–	–	–	–	–	2	–
CO-4	3	3	3	3	3	–	–	–	–	–	–	–	2	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Programmable ASIC: CLB, IOB, Memory, DSP Slices and other resources of Xilinx 7 series FPGA devices, features of Ultra scale FPGA devices, Programming technologies Partitioning and Coding Styles: Partitioning for Synthesis, General guidelines, Logic Inference.

Static Timing Analysis Concepts: CMOS Logic Design, Modeling of CMOS Cells, Min and Max Timing Paths, Clock Domains, Operating conditions, Timing Verification- Setup Timing Check, Hold Timing Check

Standard Cell Library: Pin Capacitance, Timing Modeling, Timing Models - Combinational Cells, Sequential cells

Power Analysis in ASICs: Power Computation for Basic Cells and Macros-Leakage Power Computation, Active Power Computation, Power Computation for a Flip-Flop Cell, Power Computation for a Memory Macro.

Optimizing Designs: Design Space Exploration, Compilation Strategies, Resolving multiple instance, Optimization Techniques.

Design Intent for Power Management: Power Management Requirements, Special Cells for Power Management, Architectural techniques for low power.

Learning Resources:

Text Books:

1. Michel John Sebastian Smith, Application Specific Integrated Circuits, Addison Wesley Professional, 2008.
2. Vaibbhav Taraate, ASIC Design and Synthesis: RTL Design using Verilog, Springer, 2021.

Reference Books:

1. Himanshu Bhatnagar, Advanced ASIC Chip Synthesis: Using Synopsys Design Compiler, Kluwer Academic, 2001, 2nd Edition.
2. Khosrow Golshan, Physical Design Essentials: An ASIC Design Implementation Perspective, Springer, 2007.
3. Khosrow Golshan, The Art of Timing Closure: Advanced ASIC Design Implementation, Springer, 2020.

EC2429 **3-0-0 (3)**

RF Microelectronics

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the design bottlenecks specific to RF IC design
CO-2	Identify noise sources and develop noise models for the devices and systems.
CO-3	Understand various Transmitter and receiver architectures
CO-4	Design constituent blocks of the RF receiver front end.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	1	1	1	–	–	–	–	–	–	–	–	–	–
CO-2	2	2	3	1	2	–	–	–	–	–	–	–	2	–
CO-3	2	1	1	1	–	–	–	–	–	–	–	–	–	–
CO-4	2	2	3	2	3	–	–	–	–	–	–	–	3	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Basic concepts of RF IC design: Design Bottle necks of RF IC design Non-linearity and Time invariance Sensitivity and dynamic range, Passive impedance transformation, RF radio receiver front end non-idealities and design parameters: Effects of nonlinearity, 1 dB compression point, Derivation of required noise figure at receiver front end, Required IIP_3 at receiver front end, Partitioning of required NF at receiver front end and IIP_3 into individual NF and IIP_3.

Noise: Noise sources in MOSFETs, Modeling of thermal noise and flicker noise, noise analog integrated circuits.

Transceiver architectures: General considerations, receiver architecture, Transmitter Architecture, transceiver performance tests.

Low Noise Amplifier: Introduction, General Philosophy, Matching Networks, Comparison of Narrowband and wideband LNA.
Wideband LNA Design: DC Bias, Gain ad Frequency Response, Noise Figure.
Narrowband LNA: Principles, core amplifier design, noise figure, power dissipation.

Mixers: Active mixer, modeling mixers, unbalanced mixer circuits, single balanced mixer circuit, Gilbert mixer, conversion gain.
PLL based frequency synthesizer: Concepts of PLL, phase detector, charge pump, Frequency Divider, VCO, LC oscillators, Ring oscillator, Phase noise.

Learning Resources:

Text Books:

1. Bosco Leung, VLSI for wireless communication, Prentice Hall, 2011
2. Behad Razavi, RF Microelectronics, Prentice Hall,2014

Reference Books:

1. Robert Caverly, CMOS RFIC Design Principles, Artech House Publishers, 2007.

Professional Elective - VI

EC1422 **3-0-0 (3)**

Advanced Digital Signal Processing

Pre-Requisites: **EC1305**

Course Outcomes:

CO-1	Develop adaptive filters using LMS and RLS algorithms for various applications.
CO-2	Analyze the signals using an appropriate transform technique.
CO-3	Use multi-rate signal processing techniques in various applications.
CO-4	Use statistical signal processing methods in real time applications.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	3	–	–	1	–	–	–	–	–	–	–	2	2
CO-2	2	2	–	–	1	–	–	–	–	–	–	–	2	2
CO-3	2	2	–	–	1	–	–	–	–	–	–	2	2	2
CO-4	2	3	2	–	1	–	–	–	–	–	–	2	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Adaptive Filter theory: Stochastic gradient based algorithms – LMS algorithm, stability analysis, Mean-squared error behavior. Convergence analysis, Normalized LMS algorithm, Gradient adaptive lattice algorithm. Prediction, filtering and smoothing, adaptive equalization, noise cancellation, blind deconvolution, adaptive IIR filters, RLS algorithms- GRLS, Gauss-Newton and RML.

Transform techniques: Discrete cosine transforms (DCTs), discrete sine transforms (DSTs), KL transforms, Hadamard transforms, Walsh transforms and Wavelet transforms, Applications of DCT sand Wavelets.

Multirate Digital Signal Processing: Introduction, Decimation by a Factor D, Interpolation by a Factor I, Sampling Rate Conversion by a Rational Factor I/D, Filter Design and Implementation for sampling rate Conversion. Multistage Implementation of Sampling Rate Conversion, Applications of Multirate Signal Processing, Sampling Rate Conversion of Band pass Signals.

Statistical Signal Processing: Method of least squares (LS). Recursive LS. Consistency of estimates, Observer, full and reduced order, Kalman filter, Parameter estimation, Nonparametric Estimation: Correlation and spectral analysis, Cepstrum. YuleWalker equation, Singular Value Decomposition (SVD), Higher order statistics, triple correlation and bi-spectrum.

Learning Resources:

Text Books:

1. Simon Haykin, Adaptive Filter Theory, Prentice Hall, 2013, 5th Edition.
2. J. G. Proakis & D. G. Manolakis, Digital Signal Processing - Principles, algorithms & Applications, 4th PHI.

3. Monson H. Hayes, Statistical Digital Signal Processing and modeling, John Wiley & Sons, 1996.

Reference Books:

1. James V.Candy, Signal Processing, The Model Based Approach, McGraw-Hill Book Company,1987.
2. S. K. Mitra, Digital Signal Processing – A computer Based Approach, MGH, 2010, 4th Edition.

EC1424 **3-0-0 (3)**

Wireless Communications- 5G Use Cases

Pre-Requisites: EC1303, EC1304

Course Outcomes:

CO-1	Learn 5G Technology advances and their benefits
CO-2	Learn the key RF, PHY, MAC and air interface changes required to support 5G
CO-3	Learn Interference management, mobility management, and security for 5G
CO-4	Understand the Implementation options for 5G

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	1	1	-	-	-	3	-	-	-	-	-	-	1	1
CO-2	1	1	3	-	-	-	-	-	-	-	-	-	1	-
CO-3	1	-	2	1	-	-	-	-	-	-	-	-	2	-
CO-4	1	-	-	-	-	-	-	-	-	-	-	-	1	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Introduction to Cell technologies, handoff, cellular capacity, 2G,3G, 4G standards. Basic Architectural difference in 2G, 3G & 4G systems with introduction to 5G technology. Regulations for 5G,Spectrum Analysis and Sharing for 5G.

The 5G wireless Propagation Channels: Multipath Propagation, Doppler spread, large and small-scale propagation models. Flat & frequency selective fading, Fast and slow fading, Various fading distributions, Link budgeting. Channel modeling requirements, propagation scenarios and challenges in the 5G channel modeling.

5G NR(new radio) and 5G core network (5GCN): Basics about RAN architecture, 5G RAN, ORAN, Network slicing, 5G frame structure, NFV and SDN, High-level requirements for the 5G architecture, Integration of LTE and new air interface to fulfill 5G Requirements, Enhanced Multi-RAT coordination features, Physical architecture and 5G deployment.

Transmission and Design Techniques for 5G: Basic requirements of transmission over 5G, Modulation Techniques – Orthogonal frequency division multiplexing (OFDM), generalized frequency division multiplexing (GFDM), filter bank multi-carriers (FBMC) and universal filtered multi-carrier (UFMC), Multiple Accesses Techniques – orthogonal frequency division multiple accesses (OFDMA), generalized frequency division multiple accesses (GFDMA), non-orthogonal multiple accesses (NOMA).

Interference management, mobility management, and security for 5G: Network deployment types, Ultra-dense network or densification, Moving networks, Heterogeneous networks, Interference management in 5G, Interference management in UDN, Interference management for moving relay nodes, Interference cancelation, mobility management in 5G, User equipment controlled versus network-controlled handover, Mobility management in heterogeneous 5G networks.

Learning Resources:

Text Books:

1. Martin Sauter “From GSM From GSM to LTE–Advanced Pro and 5G: An Introduction to Mobile Networks and Mobile Broadband”, Wiley-Blackwell, 2017, 2nd Edition.
2. Athanasios G.Kanatos, Konstantina S.Nikita, Panagiotis Mathiopoulos, “New Directions in Wireless Communication Systems from Mobile to 5G”, CRC Press, 2018, 1st Edition.
3. Wei Xiang, Kan Zheng, Xuemin(Sherman) Shen, 5G Mobile Communications, Springer, 2017, 1st Edition.
4. Theodore S.Rappaport, Robert W.Heath, Robert C.Danials, James N.Murdock “Millimeter Wave Wireless Communications”, Prentice Hall Communications, 2015. 1st Edition.

Reference Books:

1. Jonathan Rodriguez, “Fundamentals of 5G Mobile Networks”, John Wiley & Sons, 2015, 1st Edition.
2. Amitabha Ghosh and Rapeepat Ratasuk “Essentials of LTE and LTE-A”, Cambridge University Press, 2011, 1st Edition.

EC1426 **3-0-0 (3)**

Telecom Switching

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the characteristics of the telephone systems
CO-2	Design and test telecom switching systems
CO-3	Model and estimate the telecom traffic
CO-4	Understand the network synchronization and management
CO-5	Evaluate fiber based wide area networks

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	1	-	-	-	2	-	-	-	-	-	1	2	-
CO-2	2	3	2	-	1	-	-	-	-	-	-	1	2	2
CO-3	2	2	-	-	-	-	-	-	-	-	-	1	2	2
CO-4	1	2	-	-	-	-	-	-	-	-	-	1	2	2
CO-5	-	2	-	-	1	2	-	-	-	-	-	1	2	2

Syllabus:

Introduction – Evolution of Telecommunication, Basics of switching system, step-by-step switching, Design considerations. Principles of Crossbar switching, electronic space division switching, stored program control, software architecture, switching functions. Digital transmission, Frequency Division multiplexing, Time Division multiplexing, Statistical Division Multiplexing, switching hierarchy, Synchronous digital hierarchy other USA and European standards. Message switching, circuit switching & packet switching, space division switching, Time division switching. Two-dimensional switching, grade of service, non-blocking, digital cross connects, concentrators, expanders and distributors, two stage networks, three stage networks, n-stage networks.

Time Division Switching – Time Division space switching, Time division time switching, and time multiplexed space switching. Time multiplexed time switching, space – time combination switching, three stage combination switching, n-stage combination switching, signaling techniques.

Telecommunication Traffic – Units of Traffic, Network traffic load and parameters, Grade of service and Blocking Probability, traffic measurement, Mathematical model, Incoming traffic and service time characteristics, Blocking models and loss estimates, delay systems.

Digital Subscriber access – ISDN, High data rate digital subscriber loops, Digital Loop carrier systems, fiber in the loop, voice band modems, digital satellite services, Broadband switching systems.Network

synchronization control and management, timing, timing inaccuracies, network synchronization, network control and management.

SONET/SDH – SONET multiplexing overview, frame formats, operation, administration and maintenance, frequency justification and payload framing, virtual tributes, DS3 payload mapping, E4 payload mapping, SONET optical standards, SONET rings &networks.

Learning Resources:

Text Books:

1. John C Bellamy, Digital Telephony, Wiley-India,2000, 3/e.
2. T Viswanathan, Telecommunication Switching Systems and Networks, PHI, 2015, Second Edition.
3. J E Flood, Telecommunications Switching, Traffic and Networks, Pearson,2004.

Reference Books:

1. Gokhale, Introduction to Telecommunications, Cengage Learning,2005, Second Edition.
2. Robert G Winch, Telecommunication Transmission Systems, Tata McGraw Hill,2004, 2/e.

EC1428 **3-0-0 (3)**

Speech Processing

Pre-Requisites: **None**

Course Outcomes:

CO-1	Model speech production system and describe the fundamentals of speech.
CO-2	Extract and compare different speech parameters.
CO-3	Choose an appropriate statistical speech model for a given application.
CO-4	Design a speech recognition system.
CO-5	Use different speech synthesis techniques

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	1	–	–	1	2	–	–	–	–	–	–	2	-
CO-2	2	3	–	–	1	–	–	–	–	–	–	–	2	2
CO-3	2	3	–	–	1	–	–	–	–	–	–	–	2	2
CO-4	-	3	3	–	1	–	–	–	–	–	–	–	2	2
CO-5	-	3	–	–	1	–	–	–	–	–	–	2	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Basic Concepts: Speech Fundamentals: Articulatory Phonetics – Production and Classification of Speech Sounds; Acoustic Phonetics – Acoustics of speech production; Review of Digital Signal Processing concepts; Short-Time Fourier Transform, Filter-Bank and LPC Methods.

Speech Analysis: Features, Feature Extraction and Pattern Comparison Techniques: Speech distortion measures– mathematical and perceptual – Log–Spectral Distance, Cepstral Distances, Weighted Cepstral Distances and Filtering, Likelihood Distortions, Spectral Distortion using a Warped Frequency Scale, LPC, PLP and MFCC Coefficients, Time Alignment and Normalization – Dynamic Time Warping, Multiple Time – Alignment Paths

Speech Modeling: Hidden Markov Models: Markov Processes, HMMs – Evaluation, Optimal State Sequence – Viterbi Search, Baum-Welch Parameter Re-estimation, and Implementation issues.

Speech Recognition: Large Vocabulary Continuous Speech Recognition: Architecture of a large vocabulary continuous speech recognition system – acoustics and language models – n-grams, context dependent sub-word units; Applications and present status.

Speech Synthesis: Text-to-Speech Synthesis: Concatenative and waveform synthesis methods, sub-word units for TTS, intelligibility and naturalness – role of prosody, Applications and present status.

Learning Resources:

Text Books:

1. Lawrence Rabiner and Biing-Hwang Juang, Fundamentals of Speech Recognition, Pearson Education, 2003.
2. Thomas F Quatieri, Discrete-Time Speech Signal Processing – Principles and Practice, Pearson Education, 2004.

Reference Books:

1. Daniel Jurafsky and James H Martin, Speech and Language Processing – An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition, Pearson Education, 2002.
2. Frederick Jelinek, Statistical Methods of Speech Recognition, MIT Press, 1997.
3. Steven W. Smith, The Scientist and Engineer's Guide to Digital Signal Processing, California Technical Publishing, 1997.
4. Claudio Becchetti and Lucio Prina Ricotti, Speech Recognition, John Wiley and Sons, 1999.
5. Ben Gold and Nelson Morgan, Speech and Audio Signal Processing, Processing and Perception of Speech and Music, Wiley- India Edition, 2006.

Other suggested Readings:

1. https://nptel.ac.in/courses/117/105/117105145/

Professional Elective - VII

EC1430 **3-0-0 (3)**

Optimization Techniques

Pre-Requisites: **None**

Course Outcomes:

CO-1	Able to formulate mathematical models of real-world problems.
CO-2	Understand the major limitations and capabilities of deterministic operations
CO-3	Handle, Solve and analyse problems using linear programming and other mathematical programming algorithms.
CO-4	Solve various multivariable optimization problem.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	2	1	–	–	–	–	–	–	–	–	2	2	2
CO-2	3	2	1	–	–	–	–	–	–	–	–	–	2	2
CO-3	3	2	1	_	–	–	–	–	–	–	–	–	2	2
CO-4	3	2	1	–	–	–	–	–	–	–	–	–	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Statement of an optimization problem, Classification of optimization problems, Overview of various optimization Techniques, The simplex optimization technique, Applications of Simplex, Test Functions, Examples

Unconstrained optimization: Definitions and existence conditions, General properties of minimization algorithms, Line search, The Steepest-Descent Optimization Technique, Newton‘s method, The Least-path Optimization Technique- Least square Algorithm.

Constrained optimization: Active Constraints versus Inactive constraints, Transformations, penalty functions Advanced Techniques for Optimization:

Genetic algorithm (GA): Fundamentals of Genetic algorithm, History, Basic concepts, working principle, Applications of GA for standard Bench mark test functions.

Swarm intelligence: Main inspiration source, early variants of PSO, Basic particle swarm optimization, Initialization techniques, Theoretical investigations and parameter selection, Design of PSO algorithm using computational statistics, Termination conditions. Application of PSO, Standard test function optimization.

Differential Evaluation: Classical differential evaluation- An outline, Mutation, cross over, selection

Teaching Learning Based Optimization: Applications of TLBO for standard Bench mark test functions, Case studies

Learning Resources:

Text Books:

1. Richard W Daniels, An Introduction to Numerical Methods and Optimization Techniques, Elsevier North Holland Inc.
2. Milani Mitchel, An introduction to Genetic algorithms, MIT Press, 1998.
3. AE Eiben and J.E Smith, Introduction to Evolutionary Computing, Springer 2010.

Reference Books:

1. S Rajasekharan, G.A Vijaya Lakshmi Pai, Neural Networks, Fuzzy logic, and Genetic algorithms, Synthesis and Applications, Prentice hall of India, 2007.
2. Weifan Wang, Xuding Zhu, Ding-Zhu Du, Combinatorial Optimization and Applications:5th International Conference, Springer Publications, 2011.

EC1432 **3-0-0 (3)**

Radar Engineering

Prerequisites: None

Course Outcomes:

CO-1	Understand the basic operation of pulse and CW radar systems.
CO-2	Evaluate the radar performance based on pulse width, peak power and beam width.
CO-3	Choose suitable tracking radar for a given problem.
CO-4	Select appropriate criterion for detecting a target.
CO-5	Understand the working of phased array radars and navigational a

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	–	–	–	–	–	–	–	–	–	–	–	2	–
CO-2	–	3	–	–	–	–	–	–	–	–	–	–	2	2
CO-3	2	2	–	_	–	1	–	–	–	–	–	–	2	2
CO-4	2	–	–	–	1	–	–	–	–	–	–	–	2	2
CO-5	2	2	–	–	–	–	–	–	–	–	–	2	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Radar and Radar Equation: Introduction, Radar block diagram and operation, frequencies, applications, types of displays, derivation of radar equation, minimum detectable signal, probability of false alarm and threshold detection, radar cross-section, system losses.

CW Radar: Doppler Effect, CW Radar, applications, FM – CW radar, altimeter, Multiple Frequency Radar. Pulse Radar – MTI, Delay Line Canceller, Multiple Frequencies, Range-gated Doppler Filters, Non-coherent MTI, Pulse Doppler Radar.

Tracking Radar: Sequential lobing, conical scanning, monopulse, phase comparison monopulse, tracking in range, comparison of trackers.

Detection: Introduction, Matched Filter, Detection Criteria, Detector characteristics.

Phased Arrays: Basic concepts, feeds, phase shifters, frequency scan arrays, multiple beams, applications, advantages and limitations. Navigational Aids: Direction Finder, VOR, ILS and Loran

Learning Resources:

Text Books:

1. M.I. Skolnik, Introduction Radar Systems, Second Edition, Mc Graw Hill Book Co., 2002, 3e.
2. F.E. Terman, Radio Engineering, Mc Graw Hill Book Co. (for Chapter 7 only), 1955, Fourth Edition.

3. Simon Kingsley & Shaun Quegan, Understanding RADAR Systems, McGraw Hill Book Co., 1993.

Reference Books:

1. Byron Edde, Radar Principles, Technology, Applications, Pearson Education, 2004.
2. Peebles. Jr, Radar Principles, P.Z. Wiley.New York, 1998.
3. Mark A. Rkhards, James A. Scheer, William A. Holm Principles of Modem Radar: Basic Principles-,Yesdee, 2013

Other suggested Readings:

1. https://nptel.ac.in/courses/108/105/108105154/
2. Robert O'Donnell. RES.LL-001 Introduction to Radar Systems. Spring 2007. Massachusetts Institute of Technology: MIT Open Course Ware, https://ocw.mit.edu. License: Creative Commons BY-NC-SA.

EC1434 **3-0-0 (3)**

Software Defined Radio

Pre-Requisites: **None**

Course Outcomes:

CO-1	Conceptualize the SDR and implementation details
CO-2	Identify the blocks of SDR for a specific application
CO-3	Recognize the challenges in the implementation of SDR
CO-4	Analyze the transmitter and receiver architectures in SDR

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	–	2	–	–	2	–	–	–	–	–	–	–	2	2
CO-2	1	2	–	–	2	–	–	–	–	–	–	–	2	2
CO-3	–	–	–	_	3	2	1	–	–	–	–	–	2	2
CO-4	–	–	–	–	3	2	1	–	–	–	–	2	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction – Software Defined Radio: A Traditional Hardware Radio Architecture, limitations of HDR, Advantages of using SDR, Applications of SDR.

A Basic Software Defined Radio Architecture: Introduction – 2G Radio Architectures- Hybrid Radio Architecture- Basic Software Defined Radio Block Diagram- SDR limitations. System Level Functioning Partitioning- Digital Frequency Conversion Partitioning.

RF System Design: Introduction- Noise and Channel Capacity- Link Budget- Receiver Requirements- Multicarrier Power Amplifiers- Signal Processing Capacity Tradeoff. Introduction to Analog-to-Digital and Digital-to-Analog Conversion, Fundamentals - Sample Rate - Band pass Sampling – Oversampling - Anti alias Filtering – Quantization. Digital Frequency Up- and Down Converters- Introduction- Frequency Converter Fundamentals- Digital NCO- Digital Mixers- Digital Filters- Half band Filters- CIC Filters- Decimation, Interpolation, and Multi rate Processing-DUCs - Cascading Digital Converters and Digital Frequency Converters.

Signal Processing Hardware Components: Introduction- SDR Requirements for Processing Power- DSPs- DSP Devices- DSP Compilers- Reconfigurable Processors- Adaptive Computing Machine- FPGAs

Software Architecture and Components: Introduction- Major Software Architecture Choices – Hardware–Specific Software Architecture-Software Standards for Software Radio-Software Design Patterns- Component Choices- Real Time Operating Systems- High Level Software Languages- Hardware Languages.

Smart Antennas for Software Radio: Introduction - 3G smart Antenna Requirements-Phased Antenna Array Theory- Applying Software Radio Principles to Antenna Systems- Smart Antenna Architectures- Optimum Combining/ Adaptive Arrays- DOA Arrays- Beam Forming for CDMA- Downlink Beam Forming.

Learning Resources:

Text Books:

1. Paul Burns, Software Defined Radio for 3G, Artech House,2002.
2. Tony J Rouphael, RF and DSP for SDR, Elsevier Newnes Press,2008

Reference Books:

1. JoukoVanakka, Digital Synthesizers and Transmitter for Software Radio, Springer,2005.
2. P Kenington, RF and Baseband Techniques for Software Defined Radio, Artech House,2005.

EC2428 **3-0-0 (3)**

CAD for IC Design

Pre-Requisites: **None**

Course Outcomes:

CO-1	Specify routing techniques in IC design.
CO-2	Incorporate timing analysis and floor planning.
CO-3	Design the IC with programmable structures.
CO-4	Implement EDA/CAD with machine intelligence.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	1	3	–	2	–	–	–	–	–	1	2	2	–
CO-2	2	2	3	2	2	–	–	–	–	–	1	2	2	–
CO-3	2	2	3	2	3	–	–	–	–	–	1	2	2	–
CO-4	2	2	3	–	3	–	–	–	–	–	1	2	2	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Design Methodologies: The VLSI Design Problem, Design Methods and Technologies, Layout Methodologies, Top-Down Approach; Routing: Fundamentals, Global Routing, Detailed Routing; Performance Issues in Circuit Layout: Delay Models, Timing Driven Placement, Timing Driven Routing, Power Minimization.

Single-Layer Routing and Applications: Planar Subset Problem, Single-Layer Global Routing, Over-the-cell Routing, Multichip Modules, Wire-Length and Bend Minimization Techniques.

Cell Generation and Programmable Structures: Programmable Logic Arrays, Transistor chaining, Weinberger Arrays and Gate Matrix Layout, CMOS Cell Layout Styles Considering Performance Issues, Compaction: 1D Compaction, 2D Compaction.

Machine Intelligence in EDA/CAD: Intro to Machine Learning in EDA/CAD, Develop EDA and CAD applications like resistance estimation, Error Analysis, capacitance estimation, cell classification etc.

Learning Resources:

Text Books:

1. S.H. Gerez, Algorithms for VLSI Design Automation, Wiley, 2006.

Reference Books:

1. M. Sarrafzadeh and C. K. Wong, an Introduction to VLSI Physical Design, McGraw Hill, 1996.

Other suggested Readings:

1. https://nptel.ac.in/courses/106/105/106105161/
2. https://nptel.ac.in/courses/106/106106106088/
3. https://nptel.ac.in/courses/106/106/106106089/

Professional Elective - VIII

EC1436 **3-0-0 (3)**

Cloud based Technologies

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify the appropriate cloud services for a given application
CO-2	Analyze Cloud infrastructure including Google Cloud and Amazon Cloud.
CO-3	Analyze authentication, confidentiality and privacy issues in Cloud computing environment.
CO-4	Determine financial and technological implications for selecting cloud computing platforms

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	3	2	2	1	–	–	–	1	–	–	–	2	2
CO-2	2	3	2	2	3	–	–	–	1	–	–	–	2	2
CO-3	2	3	2	2	1	–	–	–	1	–	–	–	2	2
CO-4	2	2	3	3	3	–	–	–	1	–	–	–	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Cloud Computing Architecture, Cloud Delivery Models, The SPI Framework, SPI Evolution, The SPI Framework vs. the Traditional IT Model, Cloud Software as a Service (SaaS), Cloud Platform as a Service (PaaS), Cloud Infrastructure as a Service (IaaS) Google Cloud Infrastructure - Google File System – Search engine – Map Reduce - Amazon Web Services - REST APIs - SOAP API - Defining Service Oriented Architecture, Combining the cloud and SOA, Characterizing SOA, Loosening Up on Coupling, Making SOA Happen, Catching the Enterprise Service Bus, Telling your registry from your repository, Cataloging services, Understanding Services in the Cloud.

Serving the Business with SOA and Cloud Computing, Query API: User Authentication Connecting to the Cloud – OpenSSH Keys - Tunneling / Port Forwarding - Simple Storage Service - S3, EC2 - EC2 Compute Units, Platforms and storage, EC2 pricing, EC2 customers Amazon Elastic Block Storage - EBS - Ubuntu in the Cloud - Apache Instances in EC2 – Amazon Cloud Services- Amazon Elastic Compute Cloud (Amazon EC2), Amazon Simple DB, Amazon Simple Storage Service (Amazon S3), Amazon Cloud Front, Amazon Simple Queue Service (Amazon SQS), Amazon Elastic Map Reduce, Amazon Relational Database Service (Amazon RDS) , EC2 Applications - Web application design - AWS EC2 Capacity Planning – Apache Servers - Mysql Servers - Amazon Cloud Watch - Monitoring Tools.

Learning Resources:

Text Books:

1. Anthony T Velte, Toby J Velte, Robert Elsenpeter, Cloud Computing: A Practical Approach, MGH, 2010.
2. Gautam Shroff, Enterprise Cloud Computing, Cambridge, 2010.

Reference Books:

1. Ronald Krutz and Russell Dean Vines, Cloud Security, First Edition, Wiley, 2010.
2. Arshdeep Bahga, Vijay Madisetti, Cloud Computing: A Hands-on Approach, Universities Press (India) Private Limited, 2014
3. Rajkumar Buyya, James Broberg, Andrzej Goscinski, Cloud Computing Principles and Paradigms, Wiley, 2011

Other suggested Readings:

1. https://nptel.ac.in/courses/106/105/106105223/
2. https://onlinecourses.nptel.ac.in/noc24_cs17/preview

EC1438 **3-0-0 (3)**

Adhoc Networks

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify the components of Wireless Sensor Networks
CO-2	Understand the challenges in network coverage and routing for energy efficiency
CO-3	Define node Architecture for specific applications
CO-4	Program sensor network platforms using specialized operating system
CO-5	Recognize upcoming challenges in Sensor Networks.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	-	3	-	-	-	-	-	-	-	-	-	-	-	-
CO-2	-	1	-	-	2	-	-	-	-	-	-	-	1	-
CO-3	-	2	-	-	1	-	1	-	2	-	3	-	1	-
CO-4	-	2	-	-	1	-	1	-	-	-	-	-	-	-
CO-5	-	2	-	-	-	-	1	-	-	-	-	3	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Constraints and Challenges, Opportunities and Challenges in Wireless Sensor Networks, Advantages of Sensor Networks (Energy Advantage and Detection Advantage), Sensor Network Applications, Smart Transportation, Collaborative Processing

Sensor Network Architecture and Applications: Introduction, Functional Architecture for Sensor Networks, Sample Implementation Architectures, Classification of WSNs, Characteristics, Technical Challenges, and Design Directions, Technical Approaches, Coverage in Wireless Sensor Networks, Location in Wireless Sensor Networks, Data Gathering and Processing

Infrastructure Establishment: Topology Control, Clustering, Time Synchronization, Localization and Localization Services

Sensor Network Platforms and Tools: Individual Components of SN Nodes, Sensor Network Node, WSNs as Embedded Systems, Sensor Node Hardware, Sensor Network Programming Challenges.

Taxonomy of Routing Techniques: Routing Protocols, Applications/Application Layer Protocols, Localization Protocols, Time Synchronization Protocols, Transport Layer Protocols, Network Layer Protocols, Data Link Layer Protocols

Learning Resources:

Text Books:

1. F. ZHAO, C GUIBAS, Wireless Sensor Networks, Elsevier, Morgan Kaufmann, 2004.
2. MOHAMMAD ILYAS, IMAD MAHGOUB, Hand book of Sensor Networks, CRC Press, 2005.

Reference Books:

1. C. Siva Ram Murthy, and B. S. Manoj, "AdHoc Wireless networks ", Pearson Education - 2008.
2. Jochen Schiller, "Mobile Communications", Pearson Education, 2nd Edition, 2003.
3. William Stallings, "Wireless Communications and Networks ", Pearson Education - 2004

Other suggested Readings:

1. https://nptel.ac.in/courses/106/105/106105160/
2. http://cse.iitkgp.ac.in/~smisra/course/wasn.html

EC1440 **3-0-0 (3)**

Biomedical Instrumentation and Signal Processing

Pre-Requisites: **EC1203**, **EC1305**, **EC1325**

Course Outcomes:

CO-1	Understand and analyze the dynamic characteristics of biomedical systems and modelling
CO-2	Apply the methods of measuring biomedical signals in the design and development of medical equipment
CO-3	Specific mathematical techniques and solved problems in ECG signals Implement various signal processing techniques to model EEG signals
CO-4	Design and develop machine learning techniques for biomedical signals

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	1	1	-	-	-	-	-	-	-	3	-	3	1	1
CO-2	1	-	-	-	-	2	2	-	-	-	-	-	1	1
CO-3	1	-	3	-	-	2	2	-	-	3	3	3	1	1
CO-4	1	-	-	-	-	-	-	-	-	-	3	3	1	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

The nature of biomedical signals: cell resting potential and action potential – origin of bio potentials – characteristics – frequency sand amplitude ranges electrocardiogram (ECG), electroencephalogram (EEG) electromyogram (EMG) etc., biomedical signal origin & dynamics of ECG, ECG: ECG lead system, ECG signal characteristics; non-stationarities in ECG signal, cardiac arrhythmias, EEG data acquisition EEG lead system, EEG signal characteristics. Linear prediction and spectral estimation, modeling: Auto-regressive and moving average.

Diagnostic and Therapeutic equipment: Blood pressure monitors-Electro-cardio scope- Pulse Oximeter-Ph Meter – Auto analyzer – Pacemakers- Defibrillator – Heart lung machine- Nerve and muscle stimulators-Dialysis machines- Surgical diathermy equipment- Nebulizer; inhalator- Aspirator-Humidifier – ventilator and spirometry

Cardiological signal processing: Time domain analysis of ECG: Cardiac Arrhythmia Detection, Preprocessing of ECG -Filtering for removal of artifacts: signal averaging, limitations, ECG signal processing in time domain: Real time QRS detection algorithm, Frequency domain analysis of ECG: FFT Algorithm, Higher order spectral analysis of ECG. Multi resolution analysis of ECG signal. Estimation of heart rate in ECG- Harmonic analysis Heart rate monitoring, Pitch detection, Filtering for Removal of artifacts in ECG adaptive filtering, LMS adaptive algorithm- steepest descent algorithm, Weiner filters,50-Hz adaptive noise cancelling, Cancellation of maternal ECG in fetal electrocardiography, ECG data reduction techniques.

Neurological signal processing: Analysis of EEG, EEG rhythms, Detection of neurological disorders, Template matching for EEG, spike and wave detection. Estimation of the spectrum in EEG, Modeling EEG-linear, stochastic models - Nonlinear modeling of EEG - artifacts in EEG & their characteristics and processing Nonparametric spectral analysis, Model based spectral analysis -EEG segmentation Joint Time-Frequency analysis correlation analysis of EEG channels - coherence analysis of EEG channels. Evoked potentials- noise characteristics, Noise reduction by linear filtering, Blind source separation: Use of principal component analysis (PCA) and independent component analysis (ICA) for filtering, Multi resolution analysis of EEG signals

Machine Learning for Biomedical Signal Processing: Introduction to Machine learning and algorithms for bio-medical signals: SVM, K-Means, Naive-Bayes, Decision Tree, Random Forest, Neural Networks (Multi-Layer Perceptron and Random Basis Function) and Deep Neural Networks for classification of cardiac disorders and brain disorders. Implement above biomedical signal processing techniques in MATLAB as Assignments.

Learning Resources:

Text Books:

1. John G Webster, "Medical Instrumentation - Application and Design", John Wiley and Sons, 2009, 4th ed.
2. Leslie Cromwell, Fred. J. Weibell, Erich. A. Pfeiffer, "Biomedical Instrumentation & Measurements, Pearson Education., 2001, 2nd ed.
3. Cohen.A, Biomedical Signal Processing -Vol. I Time & Frequency Analysis - 1986, CRC Press.
4. Rangaraj M. Rangayyan, Biomedical Signal Analysis, Wiley-IEEEPress, 2015, 2nd Edition.

Reference Books:

1. Willis J Tompkins, Biomedical Digital Signal Processing, Prentice Hall India Private Limited, First Edition, 2006.
2. Eugene N. Bruce, Biomedical Signal Processing and Signal Modeling, John Wiley & Sons, 2000.
3. Adam Gacek, ECG Signal Processing, Classification and Interpretation _A Comprehensive Framework of Computational Intelligence", WitoldPedrycz Editors, Springer
4. https://nptel.ac.in/courses/108/105/108105101/

EC1442 **3-0-0 (3)**

IPR & Cyber Laws

Pre-Requisites: **None**

Course Outcomes:

CO-1	Explain origin and development of IPRs
CO-2	Understand the economic importance of IPRs
CO-3	Understand the international development of cyber laws
CO-4	Understand the relation between IPR and Cyber laws

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	–	–	–	–	–	2	–	1	–	–	–	1	–	–
CO-2	–	–	–	–	–	2	–	2	1	2	1	1	1	2
CO-3	–	–	–	–	–	1	1	1	–	–	1	1	–	–
CO-4	–	–	–	–	–	1	–	2	1	1	–	1	–	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Nature and Concept; Meaning; Types of Intellectual Property Rights; Nature of Intellectual Property Rights; Historical Background; Technological Development of IPR; Sustainable Development; Challenges for IPR system; Role of Government in fostering the IPR

IP Jurisprudence: Justification and Rationale for Protecting Intellectual Property; Basic elements of Property and Constitutional Aspects of Property and its Protection; Economic importance of Intellectual Property; Commercialization aspects of IPR; Development and IP; Overview of Intellectual Property Law – to cover the various categories and its interplay in innovation and technology delivery mechanisms.

International & National Regime: Introduction to the leading international instruments concerning intellectual property rights: the Berne Convention, Universal Copyright Convention, the Paris Convention, the Rome Convention, Trade Related Aspects of Intellectual Property Rights (TRIPS), the World Intellectual Property Rights Organization (WIPO) and the UNESCO; Background to the national regime; Evolution and development of IPR in India.

Cyber Law and IPRs: Understanding Copy Right in Information Technology - Software

Copyrights Vs Patents debate: Authorship and Assignment Issues - Copyright in Internet - Multimedia and Copyright issues - Software Piracy –Patents - Understanding Patents - Indian

Position on Computer related Patents: Trademarks - Trademarks in Internet - Domain name registration - Domain Name Disputes & WIPO - Databases in Information Technology - Protection of databases

Learning Resources:

Text Books:

1. Ananth Padmanabhan, Intellectual Property Rights: Infringement and Remedies, Lexis Nexis, Nagpur, 2012.
2. N.S. Gopalakrishnan, Principles of Intellectual Property, EBC, Lucknow, 2014.
3. Bently and Sherman, Intellectual Property Law, Oxford University Press, U.K.,2018, 5e.

Reference Books:

1. Paul Torremans, Holyoak &Torremans Intellectual Property Law, Oxford Univ.Press, 2010, Cyber Laws:
2. Justice Yatindra Singh, Cyber Laws, Universal Law Publishing, UP, 2016.

Open Electives

EC1475 **2-0-0 (2)**

Communication Systems

Pre-Requisites: None

Course Outcomes:

CO-1	Understand different modulation and demodulation schemes for analog communications.
CO-2	Design analog communication systems to meet desired application requirements
CO-3	Evaluate fundamental communication system parameters, such as bandwidth, power, signal to quantization noise ratio etc.
CO-4	Elucidate design tradeoffs and performance of communications systems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	–	–	–	3	2	–	–	–	–	–	3	1	–
CO-2	–	3	–	–	3	2	–	–	2	-	-	3	2	2
CO-3	2	–	–	–	3	-	-	-	–	–	-	3	1	–
CO-4	–	–	–	–	–	3	–	–	2	1	–	3	2	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Signal Analysis: Communication Process, Sources of Information, Communication Channels, Modulation Process, Types of Communication, Random Process, Gaussian Process, Correlation Function, Power Spectral Density, Transmission of Random Process through an LTI Filter.

Noise Analysis: External Noise, Internal Noise, White Noise, Narrow Band Noise, Representation of Narrow Band noise in phase and Quadrature Components, Noise Figure, Noise Bandwidth, Noise Temperature.

Amplitude (Linear) Modulation: Linear Modulation Schemes, Generation of AM, Envelope Detector, DSB-SC Product Modulator, Switching Modulator, Ring Modulator, Coherent Detection, Costas receiver, SSB Signal Representation, Filtering Method, Phase Shift Method, Coherent Demodulation, VSB Modulator and Demodulator, Carrier Acquisition using Squaring Loop and Costas Loop, Receiver Model, SNR, Noise in SSB and DSB receivers using coherent detection, Noise in AM Receiver using Envelope detection, Threshold Effect.

Angle (Exponential) Modulation: Types of Angle Modulation, Relation between FM and PM, Narrow Band FM, Wideband FM, Transmission Bandwidth of FM Signals, Generation of FM using Direct and Indirect methods, FM Demodulation using Slope Circuit, Frequency Discriminator, Interference in Angle Modulation, Noise in FM Receiver, FM Threshold Effect, Pre-emphasis and De-emphasis in FM, Model of PLL for FM Demodulation.

Pulse Modulation: Sampling Process, PAM, PWM, PPM, Quantization, PCM, TDM, Digital Multiplexer Hierarchy, DM, DSM, Linear Prediction, DPCM, ADPCM, Noise in PCM System, Companding, Comparison of the Noise Performance of AM, FM, PCM and DM.

Information Theory: Uncertainty, Information, Entropy, Source Coding Theorem, Data Compaction, Mutual information, Channel Capacity, BSC Channel, Information Capacity Theorem, Bandwidth - Power Tradeoff, Huffman Coding.

Learning Resources:

Text Books:

1. S. Haykin, Communication Systems, Fourth Edition, John Wiley & Sons, Singapore, 2001.
2. B.P. Lathi, Modern Digital & Analog Communication Systems, Oxford University Press, Chennai, 1998, 3rd edition.

Reference Books:

1. Leon W.Couch II., Digital and Analog Communication Systems, Sixth Edition, Pearson Education inc., New Delhi, 2001.
2. A Bruce Carlson, PB Crilly, JC Rutledge, Communication Systems, Fourth Edition, MGH, New York, 2002.

EC1476 **2-0-0 (2)**

Microprocessors and Microcontrollers

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the architecture and instruction set of 8086 microprocessor and 8051 microcontroller
CO-2	Design and develop various interfacing circuits with 8086 using 8255
CO-3	Understand the concepts of interrupt mechanism and serial communication
CO-4	Develop various applications by interfacing various modules to 8051

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	–	–	–	–	–	2	–	1	–	–	–	1	–	–
CO-2	–	–	–	–	–	2	–	2	1	2	1	1	1	2
CO-3	–	–	–	–	–	1	1	1	–	–	1	1	–	–
CO-4	–	–	–	–	–	1	–	2	1	1	–	1	–	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Microprocessor Architecture Introduction and evolution of Microprocessors–Architecture of 8086–Register Organization of 8086–Memory organization of 8086– General bus operation of 8086–Introduction to 80286–80386 and 80486 and Pentium.

Minimum and Maximum Mode Operations Instruction set, addressing modes–Minimum and Maximum mode operations of 8086–8086 Control signal interfacing–Read and write cycle timing diagrams.

I/O Interface 8255 PPI: Architecture of 8255–Modes of operation– Interfacing I/O devices to 8086 using 8255–Interfacing A to D converters– Interfacing D to A converters– Stepper motor interfacing– Static memory interfacing with 8086–DMA controller (8257)–Architecture– Interfacing 8257 DMA controller–Programmable Interrupt Controller (8259)–Command words and operating modes of 8259– Interfacing of 8259–Keyboard/display controller (8279)–Architecture–Modes of operation–Command words of 8279–Interfacing of 8279

Introduction to 8051 Micro Controller: Overview of 8051 Micro Controller– Architecture– Register set–I/O ports and Memory Organization– Interrupts–Timers and Counters–Serial Communication.

Interfacing and Applications of 8051: LEDs and push buttons Interfacing, Relays and Latch connections, Keyboard interfacing, seven segment display interfacing, A/D and D/A converter interfacing

Learning Resources:

Text Books:

1. D. V. Hall, Microprocessors and Interfacing, TMGH. 2006, 2nd edition.

2. Kenneth. J. Ayala, The 8051 microcontroller, Cengage Learning, 2010, 3rd Edition.

Reference Books:

1. Barry B. Brey, The Intel Microprocessors, PHI, 2006, 7th Edition.
2. Muhammad Ali Majid, Janice Gillespie Majid and Rollin D McKinlay, The 8051 microcontroller and Embedded systems, Pearson, 2nd Edition.
3. Liu and GA Gibson,Microcomputer system 8086/8088 Family Architecture, Programming and Design", PHI, 2nd Edition
4. Ajay. V. Deshmukh, "Microcontrollers and applications", TMGH 2005

Other Suggested Readings:

1. Microcomputers: Design and applications, IIT, Delhi, Prof. Anshul Kumar, No. of Lectures: 37

SYLLABI

Minor: **Electronics and Communication Engineering**

EC1M61 **3-0-0: 3**

Digital Electronics

Pre-Requisites: **None**

Course Outcomes:

CO-1	Design combinational and sequential digital circuits, represent logic functions in multiple forms understanding the advantages and disadvantages of each.
CO-2	Understanding of CMOS transistors to realize digital logic circuits, understand basic characteristics of logic gates.
CO-3	Understand the principle of operation and design of a wide range of electronic circuits and memories RAM and ROM.
CO-4	Understand how convert signals from analog to digital and digital to analog.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	3	2	-	2	-	-	-	-	-	-	1	2	1
CO-2	2	3	2	-	2	-	-	-	-	-	-	1	2	1
CO-3	2	2	2	-	2	-	-	-	-	-	-	1	2	1
CO-4	2	2	2	-	2	-	-	-	-	-	-	1	2	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Number system and codes: Analog versus digital, merits of digital system, number systems, base conversions, complements of numbers, weighted and non-weighted codes, error detecting and correcting codes. Boolean algebra, postulates and switching algebra, completely and incompletely specified switching functions, minimization of Boolean functions using Karnaugh map and Quine Mc-Cluskey methods- their limitations.

Logic Families: Introduction to Logic Gates- AND, OR, Ex-OR, NAND, NOR, Characteristic parameters, TTL logic, CMOS logic families, Implementation of Basic gates using TTL & CMOS logic.

Combinational Logic: Principles and practices, Logic design of combinational circuits code conversion, parity generation and checking, multiplexers, de-multiplexers, encoders, decoders, buffers, tri-state buffers.

Sequential Logic: Study of Flip-Flops (SR, JK, T, D, MS), FSM's, Counter, Universal shift registers, Full adders. RAM, ROM (Cell Structures and Organization on Chip)

Data Conversion & Study of IC's: Concepts of D/A conversion, A/D conversion using the basic circuits. Study of Basic Gate IC's –AND, NAND, OR, NOR, NOT, Ex-OR, Building Block IC's – MUX, Decoder, Adder, Flip-Flops (SR, JK, T, D, Master-Slave).

Learning Resources:

Text Books:

1. S Salivahanan, Linear Integrated CircuitsTATA MC GrawHill.
2. Jain R.P, “Modern Digital Electronics”, Tata Mc GrawHill,2003, Third edition.
3. Floyd T.L., “Digital Fundamentals ", Prentice Hall, 2006, 9 th Edition.

Reference Books:

1. Anil K. Mani: Digital Electronics-Principles and Integrated Circuits, Wiley-India, 2007.
2. Herbert Taub, Schilling: Digital Integrated Electronics, TATA MC Graw Hill, 2008.

Other suggested Readings:

1. https://archive.nptel.ac.in/courses/108/105/108105132/

EC1M62 **3-0-0(3)**

Principles of Communication Systems

Pre-Requisites: None

Course Outcomes:

CO-1	Understand different modulation and demodulation schemes for analog communication
CO-2	Design analog communication systems to meet desired application requirements
CO-3	Evaluate fundamental communication system parameters, such as bandwidth, power, signal to quantization noise ratio etc.
CO-4	Elucidate design trade-offs and performance of communications systems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	-	-	2	-	-	-	1	-	-	2	1	1	2	2
CO-2	-	-	-	-	2	-	-	-	-	-	-	-	1	1	-	-
CO-3	-	1	2	2	3	-	-	-	1	-	-	1	1	1	-	1
CO-4	-	1	-	-	3	-	-	-	1	-	-	1	1	1	-	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Signal Analysis: Communication Process, Sources of Information, Communication Channels, Modulation Process, Types of Communication, Random Process, Gaussian Process, Correlation Function, Power Spectral Density.

Noise Analysis: External Noise, Internal Noise, White Noise, Narrow Band Noise, Noise Figure, Noise Bandwidth, Noise Temperature.

Amplitude (Linear) Modulation: Linear Modulation Schemes, Generation of AM, Envelope Detector, Coherent Detection.

Angle (Exponential) Modulation: Types of Angle Modulation, Relation between FM and PM, Narrow Band FM, Wideband FM, Principles of FM Demodulation.

Pulse Modulation: Sampling Process, PAM, PWM, PPM, Quantization, PCM, TDM, Digital Multiplexer Hierarchy.

Information Theory: Uncertainty, Information, Entropy, Source Coding Theorem, Data Compaction, Mutual information, Channel Capacity, Information Capacity Theorem .

Learning Resources:

Text Books:

1. S. Haykin, Communication Systems, Fourth Edition, John Wiley & Sons, Singapore, 2001.
2. B.P. Lathi, Modern Digital & Analog Communication Systems, Oxford University Press, Chennai, 1998, 3rd Edn.

Reference Books:

1. Leon W.Couch II., Digital and Analog Communication Systems, Pearson Education inc., New Delhi, 2001, Sixth Edition.
2. A Bruce Carlson, PB Crilly, JC Rutledge, Communication Systems, MGH, New York, 2002, Fourth Edition.

Other suggested Readings:

1. https://archive.nptel.ac.in/courses/108/104/108104091/

EC1M63 **3-0-0 : (3)**

Sensors and Instrumentation

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the working of different sensors and transducers
CO-2	Understand various measurements using the sensors
CO-3	Understand the components of a virtual instrumentation systems
CO-4	Explore different data acquisition methods

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	1	2	2	-	-	-	-	-	-	-	-	-	2	2
CO-2	2	1	-	-	-	-	-	-	-	-	-	-	2	-
CO-3	2	2	-	-	-	-	-	-	-	-	-	1	2	2
CO-4	1	3	-	-	-	-	-	-	-	-	-	-	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Sensors & Transducer: Definition, Classification & selection of sensors, Measurement of displacement using Potentiometer, LVDT & Optical Encoder, Proximity sensors: Inductive & Capacitive, Use of proximity sensor as accelerometer and vibration sensor, Flow Sensors: Ultrasonic & Laser, Level Sensors: Ultrasonic & Capacitive.

Measurements: Principles of Measurement: Static Characteristics, Error in Measurement, Types of Static Error Measurement of force using strain gauge, Measurement of pressure using LVDT based diaphragm & piezoelectric sensor. Measurement of temperature using Thermistor, Thermocouple & RTD, Concept of thermal imaging, Measurement of position using Hall effect sensors.

Virtual Instrumentation: Graphical programming techniques, Data types, Advantage of Virtual Instrumentation techniques, Concept of WHILE & FOR loops, Arrays, Clusters & graphs, Structures: Case, Sequence & Formula nodes, need of software-based instruments for industrial automation.

Data Acquisition Methods: Basic block diagram, Analog and Digital IO, Counters, Timers, Types of ADC: successive approximation and sigma-delta, Types of DAC: Weighted Resistor and R-2R Ladder type. HVAC and BAC Protocols.

Intelligent Sensors: General Structure of smart sensors & its components, Characteristic of smart sensors: Self calibration, Self-testing & self-communicating, Application of smart sensors: Automatic robot control & automobile engine control.Actuators.

Learning Resources:

Text Books:

1. DVS Murthy, Transducers and Instrumentation, PHI, 20132nd Edition.
2. D Patranabis, Sensors and Transducers, PHI, 2013, 2nd Edition.

3. S. Gupta, J.P. Gupta, PC interfacing for Data Acquisition & Process Control, Instrument Society of America, 1994, 2nd edition .
4. Gary Johnson / Lab VIEW Graphical Programing / McGraw Hill 1997, II Edition.

Reference Books:

1. Arun K. Ghosh, Introduction to measurements and Instrumentation, PHI, 2012, 4th Edition.
2. A.D. Helfrick and W.D. Cooper, Modern Electronic Instrumentation & Measurement Techniques, PHI – 2001.
3. Hermann K.P. Neubert, “Instrument Transducers” 2012, Oxford University Press, 2012, 2nd Edition.

EC1M64 **3-0-0 : (3)**

Introduction to Internet of Things

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand IOT design requirements
CO-2	Compare various technologies and protocols
CO-3	Study Cloud storage and intelligent analytics
CO-4	Design and experiment various applications

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	-	1	-	2	-	-	-	-	-	-	1	2	2
CO-2	-	3	1	-	1	-	-	-	-	-	-	1	2	2
CO-3	-	-	1	-	1	-	-	3	-	-	-	1	2	2
CO-4	-	-	3	-	1	-	3	-	-	-	-	1	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Architectures: IoT and the connected world, Architecture of IoT, Security issues, Opportunities for IoT, Relevance of Internet to network of Things, network management, security, mobility and longevity, desirable features of a distributed architecture for a system of things

Technologies: Wireless protocols, Connectivity options, Low-power design, range extension techniques, data-intensive IoT, MAC and routing aspects.

Data storage and analysis: Managing high rate sensor data, Processing data streams, Data consistency in an intermittently connected or disconnected environment, Identifying outliers and anomalies

Security in IOT: Threat models, Defensive strategies and examples.

Cloud Computing: Introduction, Types of Cloud Computing, Cloud Computing: A Paradigm Shift, Price and Value Models, Security and Governance, IAAS AND PAAS, SAAS, AWS, Azure, IBM Watson

Applications of IoT

Learning Resources:

Text Books:

1. Adrian McEwen, Hakim Cassimally, “Designing the Internet of Things”, Wiley 2013.
2. Naveen Balani, “Enterprise IoT”, CreateSpace Independent Publishing Platform 2016.

Reference Books:

1. Nayan B. Ruparelia, “Cloud Computing”, MIT Press 2016.

EC1M65 **3-0-0 (3)**

Fundamentals of Image Processing

Pre-Requisites: None

Course Outcomes:

CO-1	Understand different components of image processing system with examples
CO-2	Ability to describe various enhancement techniques using various processing methods
CO-3	Illustrate the concept of image transforms and compression
CO-4	Demonstrate various edge detection, segmentation and classification techniques on a given image
CO-5	Illustrate the various schemes for image representation and recognition with examples

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	3	-	3	2	-	-	-	-	-	-	-	2	2
CO-2	3	3	3	2	2	2	-	-	-	-	-	-	2	2
CO-3	3	3	3	3	3	-	-	-	-	-	-	-	2	2
CO-4	2	3	2	2	2	2	-	-	-	-	-	-	2	2
CO-5	2	3	3	3	3	2	-	-	-	-	-	-	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

INTRODUCTION: Digital Image Processing, Fundamental Steps in Digital Image Processing, Components of an Image Processing System. Digital Image Fundamentals: Elements of Visual Perception, Image Sensing and Acquisition, Image Sampling and Quantization, Some basic Relationships between Pixels.

IMAGE ENHANCEMENT: Spatial Domain: Some Basic Gray Level Transformation, Histogram Processing, Enhancement Using Arithmetic/Logic Operations, Basics of Spatial Filtering, smoothing spatial Filters, Sharpening spatial Filters. Image Enhancement in the Frequency Domain: Introduction to 2D-Fourier Transform and the Frequency Domain, Smoothing frequency-domain Filters, Sharpening Frequency-domain Filters, Homomorphic Filtering,

IMAGE TRANSFORMS AND COMPRESSION: Properties of DCT, DWT, Fundamentals – Image Compression models – Error Free Compression – Lossy compression– Image Compression standards

IMAGE SEGMENTATION:AND MACHINE LEARNING FOR CLASSIFICATION: Detection of discontinuities- Edge detection Edge Linking and Boundary detection – Thresholding Region based segmentation, feature extraction, Machine learning for classification Methods commonly used for Computer vision, including k nearest neighbors, Logistic regression, SoftMax Regression and Support Vector Machines.

IMAGE REPRESENTATION AND RECOGNITION: Boundary representation – Chain Code – Polygonal approximation, signature, boundary segments – Boundary description – Shape number – Fourier

Descriptor, moments- Regional Descriptors –Topological feature, Texture - Patterns and Pattern classes - Recognition based on matching,

Learning Resources:

Text Books:

1. Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing. Prentice Hall India/Pearson Education. 2017. 4th edition.
2. A.K.Jain, Fundamentals of Digital Image Processing. Prentice Hall India.

Other Suggested Readings:

1. William K Pratt, Digital Image Processing by 2001, John Wiley & Sons, Inc
2. Sonka, Image Processing, Analysis and Machine Vision. Cengage Publications.

SYLLABI

Honors-1: Embedded & Machine Learning Systems

EC16005 **3-0-2 (4)**

FPGA Based Systems Design

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the Digital Circuits for different applications
CO-2	Understand the architectures of programmable logic devices for implementing digital systems
CO-3	Design, develop and implement the digital circuits on FPGAs using VHDL and Verilog coding
CO-4	Develop test strategies for Digital Systems
CO-5	Design robust Digital Systems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	2	2	1	1	1
CO-2	1	1	3	1	1	1
CO-3	2	2	3	2	2	1
CO-4	1	1	2	2	2	1
CO-5	1	1	2	2	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

INTRODUCTION: FPGAs/CPLDs: Evolution of programmable devices, FPGA Design flow, Commercially available FPGA/CPLD, Building blocks of FPGAs/CPLDs, Configurable Logic block functionality, Routing structures, Input/output Block, Impact of logic block functionality on FPGA performance, Model for measuring delay.

DESIGN USING HDL's: VHDL and Verilog modeling concepts, Behavioral, Dataflow and Structural architecture descriptions: Concurrent and Sequential statements, Event driven Simulation.

DIGITAL DESIGNS BUILDING BLOCKS: Tristate buffers, multiplexers, latches, flip-flops, registers, counters, arithmetic and logic circuits (ALU Design), Finite State Machines. Adder/Subtraction, Divisors, Multipliers, Parallel prefix adders using Signed Magnitude, Complement formats & IEEE Floating Point Arithmetic's.

DESIGN METHODOLOGY: Synchronous Systems, Top-Down Design, Register Transfer Level Design, Algorithmic State Machines, and Synthesis. Design Pitfalls. Concepts of CISC & RISC MIPS Processors.

IMPLEMENTATION ISSUES: Design Case Studies using ASM**,** Hardware Testing & Design for testability, test vectors, fault analysis for Combinational and Sequential Circuits. Microprogramming,

Learning Resources:

Text Books:

1. Wayne Wolf, FPGA based digital system design, Published by Prentice-Hall.2015.
2. Cem Ünsalan Yeditepe,The Ohio State University, Digital System Design with FPGA Implementation Using Verilog and VHDL, 2017,TMH Publishers

Reference Books:

1. John V. Old Field, Richrad C. Dorf, Field Programmable Gate Arrays, Wiley, 2008.
2. Charles H.Roth,Jr., LIzy Kurian John,Digital Systems Design.
3. William J Dally and John W Poulton ,Digital System Engineering Published by Cambridge University Press
4. Joseph Cavanaugh, Digital Design and Verilog fundamentals:Cambridge University Press Published by CRC Press.
5. Franklin P Processer And David E Winkel, The Art of Digital Design: An Introduction to Top down design: Published by Prentice-Hall.

EC16002 **3-0-0 (3)**

GPU Architectures and Programming

Pre-Requisites: **MA1163, EC1205, EC1427**

Course Outcomes:

CO-1	Understand working proficiency with CUDA, algorithmic GPU programming and parallel computing
CO-2	Comprehend with classic scientific computing algorithms and problems
CO-3	Optimize GPU code and debug GPU code
CO-4	Analyze architecture specific details like memory access coalescing, shared memory usage, GPU thread scheduling
CO-5	Apply deep learning algorithms on embedded GPUs

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	1	1	3	1	1
CO-2	2	1	1	2	1	1
CO-3	2	2	1	3	1	1
CO-4	3	1	2	3	1	1
CO-5	2	1	2	3	1	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

GPU architectures: Introduction to the ideas of parallelism and the GPU programming model CPU vs GPU Parallelizing algorithms on paper, First CUDA program

CUDA programming: Hardware of Graphics Processing Units and parallel communication patterns, Brief on GPU architecture, Basics of CUDA C, Floating point precision and support on GPUs

Parallel primitives and algorithms on GPU: The CUDA programming language will be mastered while learning how to implement these algorithms., Matrix Operations, Stencil – Image Blurring, Filters, Gauss-Jacobi-Finite difference updates for PDEs, Histogram, binning 1, Reduce – Maximum and Minimum – Summation, Prefix-sum (Scan) Algorithm – Radix Sort, Generating Cummulative Distributions , Complex agorithms – N-body solutions

Optimizing GPU Applications: Coalesced Memory Transactions, Grid Blocks, Thread Blocks, domain decomposition, Asynchronous Kernels and Multistreaming Possible Items: Libraries on GPU, cuBLAS

Thrust, cuFFT, cuRAND, Multi-node GPU processing, Multi-GPU per node processing, CUDA in other languages (Python/Fortran), Scaling.

Deep learning on GPUs: Deep learning on GPUs, Combining graphics and compute, Display the results of computations– Interactive systems, Collision detection with voxelized solid (Gargoyle), Ray tracing in CUDA kernels, or ray tracing cores, Microsoft DXR (DX12 API), Vulkan, NVIDIA OptiX / RTX, NVIDIA Turing: “World‘s First Ray Tracing GPU”- Quadro RTX, Geforce RTX

Learning resources

Text Books:

1. GPUs for Graphics: OpenGL 4.0 Shading Language Cookbook, 2nd ed.
2. Jason Sanders, Edward Kandrot, CUDA by Example: An Introduction to General-Purpose GPU Programming, Publisher: Addison-Wesley Professional

EC16001 **3-0-0 (3)**

Embedded Hardware Platforms and Programming

Pre-Requisites: **MA1163, EC1205, EC1427**

Course Outcomes:

CO-1	Understand the embedded system design challenges
CO-2	Familiarize with the ARM processor architecture and programming
CO-3	Understand the various communication interfaces and protocols
CO-4	Explore the various hardware platforms for AI& ML applications
CO-5	Develop the software drivers for embedded hardware components and communication protocols

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	1	1	1	2	1
CO-2	2	1	1	2	2	1
CO-3	2	1	1	2	2	1
CO-4	3	2	2	3	2	1
CO-5	2	2	1	2	2	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Embedded Systems: Embedded systems Overview, Characteristics of embedded computing applications. Design Challenges, Common Design Metrics, Embedded systems Design flow. Processor Technology, IC Technology, Trade-offs.

Introduction to ARM Processors: Introduction to ARM processors, Evolution of ARM processors, pipeline organization, ARM Processor cores and CPU cores. Introduction to ARM Cortex-M Processors, ARM Cortex-M4 processor ‘s architecture, Programmer‘s model, Special registers, Operation Modes, Memory map, Memory access attributes and overview of Interrupts and exceptions. Keil Microcontroller Development Kit for ARM, Typical program compilation flow, Sample arithmetic and logical assembly language programs

Embedded Systems Interfacing: Serial Peripheral Interface (SPI), Inter-Integrated Circuit (I2C), RS-232, USB, CAN, IrDA, Bluetooth, Zigbee, AMBA bus protocols.

Embedded hardware platforms: Introduction and specifications of hardware SBC platforms for AI and ML applications: Raspberry Pi 4, Jetson Nano, Jetson Xavier NX, Jetson AGX Xavier, Google Coral, Rock Pi, Beagle Bone AI and PYNQ boards.

Programming on Embedded hardware platforms: Board setup, installation of libraries, and application code development in Python, C and C++ on different embedded hardware platforms.

Learning Resources:

Text Books:

1. Joseph Yiu, The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors, Newnes Publications; 2013, 3rd edition.
2. Ata Elahi-Trever Arjeski, ARM Assembly language with hardware experimentǁ, Springer Int. Publishing, 2015.
3. Santanu Chattopadhya, —Embedded System Desig, 2023, PHI, 2nd Edition.
4. Articles on Embedded hardware platforms and programming.

Reference Books:

1. Wrox, — Professional Embedded ARM Developmentǁ
2. William hohl and Christoper Hinds, —ARM assembly language fundamentals and TechniquesǁCRC,2015, 2nd edition.

EC16003 **3-0-0 (3)**

Machine Learning Algorithms and Applications

Pre-Requisites: **EC1322**

Course Outcomes:

CO-1	Design and implement machine learning solutions to regression, classification, and clustering problems.
CO-2	Appreciate the underlying mathematical relationships within and across Machine Learning algorithms and the paradigms of supervised and un-supervised learning
CO-3	Apply the algorithms to a real-world problem, optimize the models learned and report on the expected accuracy that can be achieved by applying the models
CO-4	Build and train deep neural networks and identify key architecture parameters
CO-5	Implement deep learning algorithms and solve real-world problems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	1	1	1	2	1
CO-2	2	2	1	1	2	1
CO-3	2	2	1	3	3	1
CO-4	2	2	1	2	2	1
CO-5	2	1	1	2	2	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Linear Regression: Basics of linear regression, its assumptions, limitations and industry applications. Least square based and Gradient Descent Based Regression, Multiple linear regression, Polynomial regression.

Logistic Regression: Univariate and Multivariate Logistic Regression for classification ML. Implementation in Python, evaluation metrics and industry applications are covered.

Classification Algorithms : classification algorithms, Naive Bayes: the basics of Bayes Theorem, Naive Bayes classifier and implementation in a Spam-Ham classifier, K-Nearest Neighbours Computational geometry; Voronoi Diagrams, Delaunay Triangulations, K-Nearest Neighbour algorithm; Wilson editing and triangulations

Support Vector Machine: the SVM algorithm, its working, kernels and implementation. , Tree Models: Basics of Tree models, their structure, splitting techniques, pruning and ensembles to form Random Forests are covered here.

Unsupervised Learning-Clustering: Distance measures, Different clustering methods (Distance, Density, Hierarchical), Iterative distance-based clustering; K-Means Clustering Algorithm and Image Quantization, basics of Principal Component Analysis its working and implementation in Python.

Introduction to Neural Networks: The Intuition of Neural Networks, Activation Functions in Neural Networks, Fully Connected Layer and Back Propagation, Image Classification, Loss Functions, Optimization and Regularization: Overfitting and Capacity, Cross Validation, Feature, Selection, Regularization, Hyperparameters

Convolutional Neural Networks: The CNN, its structure, layers and working. Implementation of CNN using Keras, Image classification and hyper-parameter tuning

Learning Resources:

Text Books:

1. Christopher Bishop, Pattern Recognition and Machine Learning, Springer 2006
2. M.Gopal, Applied Machine Learning, Mc Graw Hill education, 2018

Reference Books:

1. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, Introduction to Statistical Learning, Springer, 2013.
2. Richard Duda, Peter Hart, David Stork, Pattern Classification, 2nd Ed., John Wiley & Sons, 2001.
3. Tom M. Mitchell, Machine Learning, Tata McGraw Hill Education(India) Edition, 2013

EC16004 **3-0-0 (3)**

Hardware Accelerators Design for Machine Learning Models

Pre-Requisites: None

Course Outcomes:

CO-1	Explore the various DNN models and development resources
CO-2	Understand the hardware implementation strategies for DNN
CO-3	Develop the memory optimization and computational optimization techniques to DNN
CO-4	perform the near-data processing and benchmark evaluation to DNN models
CO-5	Design and implement the accelerator logic to DNN models

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	2	2	1	2	1
CO-2	2	2	3	1	2	1
CO-3	3	2	3	2	2	1
CO-4	2	2	2	2	1	1
CO-5	1	1	3	1	--	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Overview of DNNs: Convolutional Neural Networks (CNNs), Popular DNN Models, DNN development resources**:** Frameworks**,** Models, Popular Data Sets for Classification**,** And Data Sets for Other Tasks.

Evolution of hardware platforms for Deep Learning: CPUs, GPUs, FPGAs, DSPs, accelerators; Hardware considerations in inference and training**,** Accelerate Kernel Computations on CPU and GPU Platforms**,** Energy-Efficient Dataflow for Accelerators**,** DNN data handling characteristics**,** Weight Stationary (WS), Output Stationary (OS), No Local Reuse (NLR), Row Stationary (RS). Accelerating the convolution operation: Algorithms, Data flow patterns, Memory reuse Case-study on writing a custom GPU

Kernel for accelerating convolution, optimizing networks: Weight quantization, network compression, sparse operations, zero forwarding, learning with hardware in the loop, learning and inference on low-memory devices.

Memory and compute: Optimizations to CNNs such as tiling, loop optimizations, batching, quantization, pruning, Cache Blocking, four convolution strategies (Direct, GEMM, FFT and Winograd), Model-size aware and system-aware pruning of CNNs, MLPerf Benchmark for evaluating DNN accelerators.

Near-data processing: DRAM**,** SRAM**,** Non-volatile Resistive Memories**,** Sensors, co-design of DNN models and hardware: Reduce Precision, Reduced Number of Operations and Model Size. Benchmarking metrics DNN evaluation and comparison**,** Metrics for DNN Models, Metrics for DNN Hardware.

Deep Learning on Systolic Array and Tensor Processing Unit (TPU) v1 to v4 , Distinct Characteristics of Training and Inference , Architectures of TPU v1, v2, v3 and v4; comparison between their architectures , Comparison of CPU, TPU and GPU, Deep Learning on FPGA and Microsoft's Brainwave Architecture , Deep Learning techniques on FPGA; efficacy of FPGAs for binarized neural networks (BNNs)

Learning Resources:

Text Books:

1. Editors: Shiho Kim, Ganesh Chandra Deka, Hardware Accelerator Systems for Artificial Intelligence and Machine Learning, March 28, 2021, 1st Edition, Volume 122.

Learning Resources:

1. V. Sze, Y. -H. Chen, T. -J. Yang and J. S. Emer, "Efficient Processing of Deep Neural Networks: A Tutorial and Survey," in *Proceedings of the IEEE*, vol. 105, no. 12, pp. 2295-2329, Dec. 2017, doi: 10.1109/JPROC.2017.2761740.
2. https://docs.amd.com/r/2022.2-English/ug896-vivado-ip/Xilinx-Resources

SYLLABI

Honors-2: VLSI System Design

EC26001 **3-0-0 (3)**

Device Modeling

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the governing equations along with their boundary conditions.
CO-2	Develop a sound physical and intuitive understanding of semiconductor devices
CO-3	Achieve ability to make key decisions while designing applications specific semiconductor devices.
CO-4	Simulate characteristics of a simple device using MATLAB, SPICE or other tools.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	2	2	1	1	3
CO-2	2	3	1	1	1	2
CO-3	2	3	2	2	1	1
CO-4	1	2	1	1	1	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: significance of modeling

Review of crystal structure, Unit cell and Miller Indices, Doping, Band Structure, Effective Mass, Density of states, Electron Mobility, Semiconductor Statistics- Fermi- Dirac function and carrier concentration calculation.

Semiclassical Transport Theory -: Distribution Function, Boltzmann Transport Equation (BTE), Relaxation-Time Approximation (RTA), Scattering and Mobility**.**

Drift-Diffusion (DD) model: Drift-Diffusion Model Derivation and dielectric relaxation time, Taylor series expansion and Finite Difference method, Normalization, Scaling and Linearization of Poisson's Equation and Scharfetter–Gummel Discretization of the Continuity Equation, Generation and Recombination models, Derivation of SRH model, Boundary conditions, Gummel's Iteration Method and Newton's Method, Drift-Diffusion Application example.

Hydrodynamic Modeling -: As extension of DD model, Carrier Balance, Energy balance and momentum balance Equations, Direct solution scheme through Monte Carlo simulations Quantum Transport models -: Tunneling, Schrodinger equation and free particle, potential step, potential barrier, Transfer Matrix Approach, Quantum Mechanical corrections to standard approach.

Models for DD, Hydrodynamic simulations, Mobility and G-R models, Selected Examples: SPICE Diode and MOSFET Models and Their Parameters

Learning Resources:

Text Books:

1. C. Snowden, "Introduction to Semiconductor Device Modelling", World Scientific, 2011.

2. S. M. Sze and Kwok K. Ng, Physics of Semiconductor Devices, John Wiley & Sons, 3rd Edition, 2006.
3. Mark Lundstrom, Fundamentals of Nanotransistors, World Scientific, 2017.
4. Yannis Tsividis and Colin McAndrew, Operation and Modelling of the MOS Transistor, Oxford University Press, 2011.
5. Supriyo Datta, Lessons from Nanoelectronics: A New Perspective on Transport (In 2 Parts), World Scientific, 2nd Edition, 2018.

Reference Books:

1. E. Takeda, Hot-carrier Effects in MOS Transistors, Academic Press, 1995.
2. N. Arora, MOSFET Models for VLSI Circuit Simulation: Theory and Practice, Springer-Verlag Wein New York, 1993.
3. Norman G. Einspruch and Gennady Gildenblat, Advanced MOS Device Physics, Academic Press, 1989.
4. Y. Leblebici and S. M. Kang, Hot-Carrier Reliability of MOS VLSI Circuits, Springer Science + Business Media, LLC, 1993.
5. J. P. Colinge, “FinFETs and Other Multi-Gate Transistors,” Springer. 2009

Other Suggested Readings:

1. NPTEL Courses (https://archive.nptel.ac.in/courses/108/105/108105188/)

EC26002 **3-0-0 (3)**

Physical Design Automation

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the relationship between design automation algorithms and various constraints posed by VLSI fabrication and design technology.
CO-2	Adapt the design algorithms to meet the critical design parameters.
CO-3	Learn various layout optimization techniques and map them to the algorithms.
CO-4	Develop proto-type EDA tool and test its efficacy.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	1	1	1	1	1	3
CO-2	2	1	2	1	2	2
CO-3	1	1	2	1	2	3
CO-4	1	2	3	2	2	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

VLSI design Cycle, Physical Design Cycle, Design Rules, Layout of Basic Devices, and Additional Fabrication, Design styles: full custom, standard cell, gate arrays, field programmable gate arrays, sea of gates and comparison, system packaging styles, multichip modules.

Design rules, layout of basic devices, fabrication process and its impact on physical design, interconnect delay, noise and cross talk, yield and fabrication cost.

Factors, Complexity Issues and NP-hard Problems, Basic Algorithms (Graph and Computational Geometry): graph search algorithms, spanning tree algorithms, shortest path algorithms, matching algorithms, min-cut and max-cut algorithms, Steiner tree algorithms.

Basic Data Structures, atomic operations for layout editors, linked list of blocks, bin-based methods, neighbor pointers, corner stitching, multi-layer operations.

Graph algorithms for physical design: classes of graphs, graphs related to a set of lines, graphs related to set of rectangles, graph problems in physical design, maximum clique and minimum coloring, maximum k-independent set algorithm, algorithms for circle graphs.

Partitioning algorithms: design style specific partitioning problems, group migrated algorithms, simulated annealing and evolution, and Floor planning and pin assignment, Routing and placement algorithms.

Learning Resources:

Text Books:

1. Naveed Shervani, Algorithms for VLSI Physical Design Automation, Kluwer Academic, 3rd Edition, 1999
2. Andrew B. Kahng, Jens Lienig, Igor L. Markov and Jin Hu, VLSI Physical Design: From Graph Partitioning to Timing Closure, Springer, 2nd Edition, 2022.
3. Sung Kyu Lim, Practical Problems in VLSI Physical Design Automation, Springer, 2008.

Reference Books:

1. Charles J. Alpert, Dinesh P. Mehta, Sachin S. Sapatnekar, Handbook of Algorithms for Physical Design Automation, CRC Press, 2008.
2. Sabih H. Gerez, Algorithms for VLSI Design Automation, Wiley, 2nd Edition, 2008.
3. Charles J. Alpert, Dinesh P. Mehta and Sachin S. Sapatnekar, Handbook of Algorithms for Physical Design Automation, CRC Press, 2009.

EC26003 **3-0-0 (3)**

Analog IC Design

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the biasing styles and limitations
CO-2	Design CMOS analog basic building blocks
CO-3	Evaluate different CMOS amplifier topologies and design for given specifications
CO-4	Comprehend the stability issues of the systems and design two stage amplifier

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	1	1	1	_	–
CO-2	3	3	3	3	3	–
CO-3	3	3	2	3	2	–
CO-4	2	3	2	3	3	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Review of MOSFET device characteristics, second order effects, MOS small signal Model, Capacitances, body bias effect, Current biasing, voltage biasing, Technology biasing, Relative comparision and limitations

Basic building blocks and basic cells-Switches, active resistors, Current sources and sinks, Current mirrors: Basic current mirror, cascode current mirror, low voltage current mirror, Wilson and Widlar current mirrors, voltage and current references, Mismatch inaccuracies, Design solutions to minimize mismatch inaccuracies.

Single stage amplifier: Analytical justification of operating region suitable for amplification/switching , Design of CS amplifier with different loads, Limitations of diode connected load, Improving output impedance of CS amplifier through feedback ,small signal analyses of common gate and common drain topologies and their frequency response with parasitic affects, significance of cascode, design of cascode amplifier and with ideal current source load and practical cascode load, Limitations of cascode, folded cascode amplifier and design with parasitics.

Differential amplifier: Significance of differential signaling, Limitations of quasi differential amplifier, Design of differential amplifier with current source load and diode connected load and small signal analyses, errors due to mismatch, replication principle, qualitative analysis, common mode response, gilbert cell, Common centroid layout.

Operational amplifier-characterization, two stage OP amp, small signal analysis, Miller compensation, effect of RHP zero on stability, Lead compensation, constant g_m biasing, design of biasing circuit independent of process and temperature variations.

Band Gap Reference: General considerations, Supply independent biasing, temperature-independent references, negative-TC voltage, positive TC voltage, Bandgap reference, PTAT generation, curvature correction, Design of BGR under low voltage conditions.

.

Learning Resources:

Text Books:

1. Behzad Razavi, Design of Analog CMOS Integrated Circuit, McGraw Hill Education, 2nd Edition, 2017.
2. Paul J. Hurst, Paul R. Gray, Robert G Meyer and Stephen H. Lewis, Analysis and Design of Analog Integrated Circuits, Wiley, 6th Edition, 2024
3. Mohammed Ismail and Terri Fiez, Analog VLSI: Signal and Information Processing, McGrawHill, 1994.

Reference Books:

1. Randall L. Geiger, Phillip E. Allen and Noel R. Strader, VLSI Design Techniques for Analog and Digital Circuits, Tata McGraw-Hill Education, 1989.
2. David Johns, Tony Chan Carusone and Kenneth Martin, Analog Integrated Circuit Design, Wiley, 2011, 2nd Edition.
3. Paul G. A. Jespers and Boris Murmann, Systematic Design of Analog CMOS Circuits, Cambridge University Press, 2017.

Other Suggested Readings:

1. NPTEL Courses (https://nptel.ac.in/courses/117101105)

EC26005 **3-0-0 (3)**

Digital IC Design

Pre-Requisites: **None**

Course Outcomes:

CO-1	Design CMOS inverters with specified noise margin and propagation delay.
CO-2	Design an Inverter with different logic styles and analyse the performance
CO-3	Design building blocks of combinational and sequential circuits using CMOS logic
CO-4	Design Synchronous Systems meeting timing constraints.
CO-5	Study various architectures in the organization of volatile and non-volatile memories using 1-bit memory cells along with periphery circuits to improve access time and power consumption.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	1	2	3	2	-
CO-2	2	1	1	1	2	2
CO-3	2	1	1	2	3	1
CO-4	1	1	2	2	3	1
CO-5	1	1	1	2	3	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

MOS Inverters: Structure and Operation of MOS Transistor (MOSFET), MOSFET Current-Voltage Characteristics, MOSFET Scaling and Small-Geometry Effect, MOSFET Capacitances, CMOS Inverter- Static and switching characteristics, Delay-Time Definitions, Calculation of Delay Times, Inverter Design with Delay Constraints Estimation of Interconnect Parasitics, Power Consumption in CMOS Gates.

Designing Combinational & Sequential Logic Gates in CMOS: Static CMOS design- ratioed logic, pass transistor logic, transmission gate logic, Dynamic CMOS Design, Static Latches and Registers, Dynamic Latches and Registers, Alternative Register Styles, Nonbistable Sequential Circuits, Logic Style for Pipelined Structures.

Timing Issues in Digital Circuits: Introduction, Synchronous Timing basics, Clock Skew and Jitter, Clock distribution techniques, Clock Generation and Synchronization.

Designing Arithmetic Building Blocks: Introduction, The Adder: Circuit and Logic Design, Multipliers: Shifters, Power Considerations in Datapath Structures.

Designing Memory: Introduction, Semiconductor Memories - An Introduction, The Memory Core: RAM, ROM, Memory Peripheral Circuitry.

Learning Resources:

Text Books:

1. Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic, Digital Integrated Circuits: A Design Perspective, Pearson, 2nd Edition, 2003

2. John P. Uyemura, CMOS Logic Circuit Design, Springer, 2001.
3. John P. Uyemura, Introduction to VLSI Circuits and Systems, Wiley, 2002.

Reference Books:

1. Sung-Mo Kang and Yusuf Leblebici, CMOS Digital Integrated Circuits, McGraw-Hill, 3rd Edition, 2003.
2. Charles Hawkins, Jaume Segura and Payman Zarkesh-Ha, CMOS Integrated Digital Electronics: A First Course, IET, 2012.

EC26004 **3-0-0 (3)**

Mixed Signal Design

Pre-Requisites: **EC26003, EC26005**

Course Outcomes:

CO-1	Understand the necessity of mixed signal systems
CO-2	Analyze Op-Amp to meet the mixed signal specifications.
CO-3	Design CMOS comparators to meet the high-speed requirements of digital circuitry.
CO-4	Develop efficient data converter circuits for mixed signal systems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	**1**	1	**2**	**1**	**–**
CO-2	2	1	3	**2**	1	**1**
CO-3	2	1	3	**2**	3	**2**
CO-4	3	**1**	3	**3**	2	**3**

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Review of two stage OP amp: Parasitic effects on design of 2 stage OP amp, wide swing cascode current mirrors, design of rugged biasing circuit with temperature independent compensation, Challenges in mixed signal circuit design.

Switched Capacitor Circuits: Constituents: Op-Amp, Capacitors, Switches, Non-overlapping Clocks, Basic Operation and Analysis, Resistor Equivalence of a Switched Capacitor, Parasitic-Sensitive Integrator, Parasitic Insensitive Integrators, Signal-Flow-Graph Analysis. Design of filters based on switched capacitor circuits,

Sample-and-Hold Circuits: Testing Sample and Holds, MOS Sample-and-Hold Basics, Examples of CMOS S/H Circuits, Charge-Injection Errors, Making Charge-Injection Signal Independent, Minimizing Errors Due to Charge-Injection, effect of offset and application of switched capacitor circuits to minimize offset errors, Parasitic affects.

Comparators: Ideal comparator, practical model of comparator, resolving capability, propagation delay, small signal analysis, conditions for slewing, evaluation of propagation delay for single pole and two pole comparators, Design of Linear response comparators, slew-rate limited comparators, comparators with positive feedback, analysis of latched Comparators, Architecture of High-speed comparators, self-biased comparators, push pull comparators.

Data Converters: Classification, Ideal D/A Converter, Ideal A/D Converter, Quantization Noise, Deterministic Approach, Stochastic Approach, Signed Codes, Performance Limitations, Resolution, Offset and Gain Error, Accuracy and Linearity Integrating Converters, Design of Successive-Approximation

Converters, DAC-Based Successive Approximation, Charge-Redistribution A/D, Principles of Sigma-Delta ADC, Testing of data converters.

Basic Phase-Locked Loop: Architecture, Voltage Controlled Oscillator, Divider Phase Detector, Loop Filer, The PLL in Lock, Linearized Small-Signal Analysis, Second-Order PLL Model, Limitations of the Second-Order Small-Signal Model, PLL characterization and Design Example. Jitter and Phase Noise, Period Jitter, P-Cycle Jitter, Adjacent Period Jitter, other Spectral Representations of Jitter, Probability Density Function of Jitter, Ring Oscillators, LC Oscillators, phase Noise of Oscillators, jitter and Phase Noise in PLLS.

Learning Resources:

Text Books:

1. David Johns, Tony Chan Carusone and Kenneth Martin, Analog Integrated Circuit Design, Wiley, 2nd Edition, 2012.
2. Behzad Razavi, Design of Analog CMOS Integrated Circuits" McGraw Hill Education, 2nd Edition, 2017.
3. R. Jacob Baker, CMOS: Mixed-Signal Circuit Design, Wiley, 2nd Edition, 2008.

Reference Books:

1. Roubik Gregorian and Gabor C. Temes, Analog MOS integrated circuits for signal processing, Wiley, 1986.
2. Roubik Gregorian, Introduction to CMOS Op-Amps and Comparators, Wiley, 2008.
3. Rui Paulo da Silva Martins and Pui-In Mak, "Analog and Mixed-Signal Circuits in Nanoscale CMOS", Springer, 2024.

SYLLABI

Honors-3: Advanced Communication Systems

EC36005 **3-0-2 (4)**

RF Engineering

Pre-Requisites: **None**

Course Outcomes:

CO-1	Simulate passive circuits in microstrip line technology
CO-2	Design microstrip lowpass, high pass, bandpass and bandstop filters.
CO-3	Design microstrip based couplers and power dividers
CO-4	Use and measure S-parameters using microwave instruments

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	1	-	-	2	-	-
CO-2	-	-	-	-	2	-
CO-3	-	-	-	-	2	-
CO-4	-	-	-	-	-	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

SCATTERING PARAMETERS: Scattering and chain scattering matrices, Generalized scattering matrix, Analysis of two port Networks, scattering matrix, representation of microwave components (directional coupler, circulators, hybrids, and isolators).

PLANAR TRANSMISSION LINE: Microstrip lines: Geometry of microstrip, quasi-TEM mode of propagation, Static-TEM parameters, Characteristic impedance, effective permittivity, synthesis formulae, analysis formulae, dispersion in microstrip.

HIGH FREQUENCY FILTER DESIGN: Filter design using Insertion loss method, characterization by power loss ratio, Maximally flat low pass filter, Equal-ripple low pass filter, Filter transformations: impedance and frequency scaling, bandpass and bandstop transformations, Filter implementation: Richard's transformation, Kuroda's identities.

POWER DIVIDERS AND DIRECTIONAL COUPLERS: Basic properties of dividers and Couplers. Even mode and odd mode analysis, Wilkinson power divider, quadrature hybrid, and coupled line directional coupler.

MICROWAVE MEASUREMENT SYSTEMS: Instrumentation concepts and measurement techniques in Spectrum analyzer, Signal generator, Vector network analyzer, and Noise figure analyzers.

LAB Experiments

1. Design and simulation of microstrip low pass filter using 2.5D and 3D simulator (using stubs and stepped impedance filter).
2. Design and simulation of microstip bandpass filter using 2.5D and 3D simulator
3. Design and simulation of microstrip branch line coupler using using 2.5D and 3D simulator.

4. Design and simulation of microstrip coupled line coupler using using 2.5D and 3D simulator
5. Design and simulation of Wilkinson power divider using using 2.5D and 3D simulator.
6. Measurement of passive components using Vector Network Analyzer, Spectrum Analyzer and Signal Generator.
7. Fabrication and testing of microstrip low pass and bandpass filter.
8. Fabrication and testing of a microstip branch line coupler and Wilkinson power divider

Learning Resources:

Text Books:

1. D. M. Pozar, Microwave Engineering, John Wiley & Sons, 2012, 3nd Edition
2. R. Sorrentino and G. Bianchi, Microwave and RF Engineering, John Wiley & Sons, 2010
3. Reinhold Ludwig and Gene Bogdanvov, —RF Circuit Design – Theory and Application, Pearson, 2012, 2nd Edition

Reference Books:

1. E.da Silva, —High Frequency and Microwave Engineering, Butterworth Heinmann publications, Oxford, 2001.
2. T. C. Edwards, Foundations of Interconnects and Microstrip lines, John Wiley & Sons.

Other Suggested Readings:

1. https://nptel.ac.in/courses/117102012
2. https://onlinecourses.nptel.ac.in/noc23_ee36/

EC36004 **3-0-0 (3)**

Wireless Networks

Pre-Requisites: **EC1301**

Course Outcomes:

CO-1	Identify and explain the fundamental concepts of wireless network architecture, layer technologies and Wireless LAN, PAN and MAN devices.
CO-2	Represent the RF and IR communication spectrum details and propagation principles.
CO-3	Understand the concepts of wireless LAN standards, both infrastructure and Ad-Hoc and their implementation details
CO-4	Identify and explain the Wireless LAN security methodologies
CO-5	Understand wireless PAN and MAN standards and their implementation details
CO-6	Identify the important aspects of future wireless networking technologies.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	3	-	3	2	-
CO-2	3	3	3	2	2	2
CO-3	3	3	3	3	3	-
CO-4	2	3	2	2	3	2
CO-5	2	–	–	–	–	–
CO-6	2	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Introducing Wireless Networking, Wireless Network Logical Architecture, the OSI & TCP Network Models, Network Layer Technologies, Data Link Layer Technologies, Physical Layer Technologies, Wired Network Topologies, Wireless LAN Devices, Wireless PAN Devices, Wireless MAN Devices.

Wireless Communication: Radio Communication Basics, RF Spectrum, Spread Spectrum Transmission, Wireless Multiplexing and Multiple Access Techniques, Ultra-Wideband, Near Field Communications, Infrared Communication Basics.

Wireless LAN: The 802.11 WLAN Standards, 802.11 MAC Layer, 802.11 PHY Layer, Implementing Wireless LANs, A Case Study: Voice over WLAN.

Ad-Hoc Wireless Networks: MAC Protocols for Ad-hoc Wireless Networks, Classification of MAC protocols, Contention-Based Protocols, Contention-Based Protocols with Reservation Mechanisms, Contention-Based Protocols with Scheduling Mechanisms, Routing Protocols for Ad-hoc Wireless Networks, Classification of Routing Protocols; Table Driven Routing Protocols; On-Demand Routing Protocols, Hybrid Routing Protocols, Hierarchical Routing Protocols and Power-Aware Routing Protocols. Transport Layer and Security Protocols.

Security: Hacking Threat WLAN Security, WEP – Wired Equivalent Privacy Encryption, Wi-Fi Protected Access, WPA IEEE 802.11i and WPA2, WLAN Security Measures, Wireless Hotspot Security.

Wireless PAN: Wireless PAN Standards, Bluetooth (IEEE 802.15.1), Wireless USB, ZigBee (IEEE 802.15.4), IrDA, Near Field Communications, Implementing Wireless PANs, Wireless PAN Technology Choices, Pilot Testing, Wireless PAN Security, 6LoWPAN.

Wireless MAN: Wireless MAN Standards, 802.16 Wireless MAN Standards, Metropolitan Area Mesh Networks, Implementing Wireless MANs, Wireless Mesh Network Routing, Network Independent Roaming, Gigabit Wireless LANs, Cognitive Radio, Sigfox / LoRa.

Learning Resources:

Text Books:

1. Steve Rackley, Wireless Networking Technology, Elsevier, 2007.
2. Ivan Marsic Wireless Networks- Local and Ad Hoc Networks, Rutgers University, 2008.
3. Wireless Communications and Networks, William Stallings, Pearson, 2005, Second Edition.
4. A. S. Tanenbaum, Computer Networks, Third Edition, PHI, 2003.

Reference Books:

1. Koushik Sinha, Sasthi C. Ghosh, Bhabani Wireless Networks and Mobile Computing, Chapman and Hall/CRC, 2015.
2. C. Siva Ram Murthy & B. S. Manoj Ad-hoc Wireless Networks, Pearson Education, 2011, 2nd Edition

Other Suggested Readings:

1. http://doktora.kirbas.com/Kitaplar/Wireless%20Networking%20Complete.pdf
2. www.tutorialspoint.com/wimax/
3. http://www.infotech.monash.edu.au/units/archive/2012/s2/fit5083.html
4. http://www.utdallas.edu/~venky/
5. https://nptel.ac.in/courses/106105160

EC36001 **3-0-0 (3)**

Detection and Estimation Theory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Apply discrete-time and continuous-time signal theory to estimate the signal parameters.
CO-2	Extract useful information from random observations in communications.
CO-3	Design and analyze optimum detection schemes.
CO-4	Understand different estimation schemes such as ML, LSE and MMSE estimators.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	-	-	-	-	-
CO-2	-	2	-	-	-	-
CO-3	-	-	2	-	-	-
CO-4	-	-	2	-	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Detection theory

Introduction: Detection Theory in Signal Processing; the Detection Problem; Mathematical Detection Problem; Hierarchy of Detection Problems; Role of Asymptotic; Summary of Important PDFs (Fundamental Probability Density Functions); Monte Carlo Performance Evaluation, Number of required Monte Carlo trials.

Statistical Decision Theory: Neyman-Pearson Theorem; Receiver Operating Characteristics; Minimum Probability of Error (ML, MAP, Baye's); Multiple Hypothesis Testing.

Deterministic Signals: Matched Filters – Development of Detector, Performance of Matched Filter; Multiple Signals – Binary case, Performance of Binary Case, M-ary case.

Random Signals: Estimator-Correlator – Energy Detector; Linear Model – Rayleigh Fading Sinusoid, Incoherent FSK for a Multipath Channel; Signal Processing Example – Tapped Delay Line Channel Model.

ESTIMATION THEORY

Introduction: Estimation in Signal Processing; Mathematical Estimation Problem; Assessing Estimator Performance.

Minimum Variance Unbiased Estimation: Unbiased Estimators; Minimum Variance Criterion; Existence of the Minimum Variance Unbiased Estimator; Finding the Minimum Variance Unbiased Estimator.

Cramer-Rao Lower Bound: Estimator Accuracy Considerations; Cramer-Rao Lower Bound; General CRLB for Signals in WGN; Extension to a Vector Parameter; Signal Processing Examples – Range Estimation, Sinusoidal Parameter Estimation).

Linear Models: Definition and Properties; Linear Model Examples – Curve Fitting, Fourier Analysis, System Identification.

General Minimum Variance Unbiased Estimation: Sufficient Statistics; Finding Sufficient Statistics; Using Sufficiency to Find the MUV Estimator.

Best Linear Unbiased Estimators: Definition of the BLUE; Finding the BLUE.

Maximum Likelihood Estimation: Example – DC Level in WGN; Finding the MLE; Properties of the MLE; MLE for Transformed Parameters.

Least Squares Estimation: The Least Squares Approach; Linear Least Squares; Order-Recursive Least Squares.

The Bayesian Philosophy: Prior Knowledge and Estimation, Nuisance parameters

General Bayesian Estimators: Risk Function; Minimum Mean Square Error Estimators; Maximum A Posteriori Estimators.

Kalman Filters and Wiener Filters: Introduction, Summary, Dynamic signal models, Scalar Kalman filter, Kalman versus Wiener filter.

Learning Resources:

Text Books:

1. Steven M. Kay, “Fundamentals of Statistical signal processing, volume-1: Estimation theory”. Prentice Hall ,2011.
2. Steven M. Kay, “Fundamentals of Statistical signal processing, volume-2: Detection theory”. Prentice Hall , 4e”,2011.

Reference Books:

1. Harry L. Van Trees, “Detection, Estimation, and Modulation Theory, Part I,” John Wiley & Sons, Inc. 2011.
2. A. Papolis and S. Unnikrishna Pillai, “Probability, Random Variables and stochastic processes, The McGraw-Hill 2010.

Other Suggested Readings:

1. https://nptel.ac.in/courses/117103018
2. https://onlinecourses.nptel.ac.in/noc22_ee60

EC36003 **3-0-0 (3)**

Advanced Digital Communications

Pre-Requisites: **None**

Course Outcomes:

CO-1	Design optimum receivers for digital modulation techniques
CO-2	Compare the various modulation schemes from the point of view of bandwidth, circuit complexity and noise performance.
CO-3	Determine the probability of error for a given scheme
CO-4	Design an equalizer in the context of band-limited linear filter channels

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	1	-	-	2	-	-
CO-2	-	-	-	-	2	-
CO-3	-	-	-	-	2	-
CO-4	-	-	-	-	-	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Elements of a Digital Communication System, mathematical models for communication channels, Communication channels and their characteristics. Representation of bandpass signals and system, Signal space representations.

Representation of digitally modulated signals, Memoryless modulation methods-Pulse Amplitude Modulation, Phase Modulation schemes, Quadrature Amplitude Modulation, Multi dimensional signaling - Spectral characteristics of Digitally modulated signals .

Optimum receiver for signals corrupted by AWGN, Performance of the optimum receiver for memoryless modulation, Optimum receiver for CPM signals and signals with random phase in AWGN channel.

Signal parameter estimation, Carrier phase estimation, Symbol timing estimation, Joint estimation of carrier phase and symbol timing, Performance characteristics of ML estimators.

Characterization of band-limited channels, Signal design for band-limited channels, Probability of error in detection of PAM, Modulation codes for spectrum shaping.

Optimum Receiver for channels with ISI and AWGN, Linear equalization, Decision feedback equalization, Reduced complexity ML detectors, Iterative equalization and decoding-Turbo equalization.

Multicarrier Systems: Multi Carrier Communications, Orthogonal Frequency Division Multiplexing(OFDM), Modulation and Demodulation of OFDM system, Algorithm implementation IFFT/FFT of OFDM, Peak to average Power Ratio in multi carrier Modulation

Learning Resources:

Text Books:

1. J.G. PROAKIS, Digital communications, MGH, 2001, 4th edition

2. Upamanyu Madhow, Fundamentals of Digital Communication, Cambridge University Press, 2014,

Reference Books:

1. Michael Rice, Digital Communications: A Discrete-Time Approach, Pearson , 2012, Indian edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/117105144
2. https://onlinecourses.nptel.ac.in/noc21_ee11

EC36002 **3-0-0 (3)**

Advanced Wireless Communication

Pre-Requisites: **None**

Course Outcomes:

CO-1	Model the wireless channel to estimate the path loss
CO-2	Evaluate the performance of digital modulation techniques over wireless channels using software and hardware techniques
CO-3	Suggest the possible techniques to improve the performance of wireless systems using modern tools
CO-4	Identify the advantages of multicarrier modulation

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	1	-	-	2	-	-
CO-2	-	-	-	-	2	-
CO-3	-	-	-	-	2	-
CO-4	-	-	-	-	-	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

WIRELESS CHANNELS: Radio wave propagation, Physical modeling for wireless channels, Path loss and Shadowing, outage probability under path loss and shadowing, time and frequency coherence, Statistical multipath channel models, narrowband fading models, wideband fading models, Discrete-time model, Space-time channel models.

CAPACITY OF WIRELESS CHANNELS:AWGN channel capacity, capacity of flat fading channels, channel distribution Information known at transmitter or receiver and both capacity comparisons, Capacity of frequency selective fading channels-time invariant- time variant.

PERFORMANCE OF DIGITAL MODULATION OVER WIRELESS CHANNELS: SNR and bit/symbol energy, error probability for BPSK, QPSK, MPSK, MPAM, MQAM, Index Modulation over fading channels. Error probability for FSK and CPFSK, error probability approximation for coherent modulations and differential modulation, Q-function representation, outage probability, average probability of error, inter symbol interference.

DIVERSITY: Receiver diversity: selection combining (SC), maximal ratio combining (MRC), equal gain combining (EGC), transmitter diversity: channel known at the transmitter, channel unknown at the transmitter, Alamouti scheme, diversity analysis for non-coherent and differentially coherent modulation.

EQUALIZATION: equalizer noise enhancement, equalizer types, zero forcing equalizer, MMSE equalizer, maximum likelihood sequence estimation, decision feedback equalization, adaptive equalizers

Learning Resources:

Text Books:

1. Andrea goldsmith, `Wireless Communication`, Cambridge University Press ,South Asia Edition 2015.
2. Theodore S. Rappaport, “Wireless Communications Principles and Practice,'' Pearson Education., Third Edition, (Indian Edition is available).

Reference Books:

1. David Tse, Pramod Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press
2.Todd K Moon, Wynn C. Stirling," Mathematical Methods and Algorithms for Signal Processing”, Prentice Hall

Other Suggested Readings:

1. https://nptel.ac.in/courses/117104099

2 https://onlinecourses.nptel.ac.in/noc24_ee10