NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

B.Tech. in

Electronics and Communication Engineering (VLSI Design and Technology) – Course Structure

SCHEME OF INSTRUCTION

Department of

Electronics and Communication Engineering

(Effective from 2023-24)

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

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

VISION

Create an educational environment to mould the students to meet the challenges of modern Electronics and Communication industry 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 electronic industry
- To create entrepreneurial environment and industry interaction for mutual benefit
- To become a global partner in training human resources in the fields of chip design, instrumentation and networking
- To associate with internationally reputed Institutions for academic excellence and collaborative research

Department of Electronics and Communication Engineering:

Brief about the Department:

National Institute of Technology Warangal was established in 1959, and the department of Electronics and Communication Engineering has been one of the key departments of the institute since its inception in the year 1971. The department has expanded steadily over the last few decadesand is now recognized as one of the leading academic and research Centre ‘s in India.

The Department maintains very good industry-institute linkages. Majority of the students are placed in reputed companies, Government organizations and Higher Educational Institutes in India and abroad. The alumni who are important stakeholders of the Department, actively guide and provide valuable inputs. They constantly peer review the syllabus and curriculum to make students industry ready.

The faculty of the Department are actively involved in sponsored projects and have prestigious projects like-SPARC, IMPRINT, DST, SERB, DRDO to name a few. The faculty is actively engaged in providing solutions to industry problems as consultants. The academic programs of the department are rated among the top in the country.

List of Programs offered by the Department:

Name of the Program	Title of the Program
B.Tech	Electronics and Communication Engineering Electronics and Communication Engineering (VLSI Design and Technology)
M.Tech	Electronic Instrumentation and Embedded Systems
	VLSI System Design
	Advanced Communication Systems
Ph.D	Electronics and Communication Engineering

Note: Refer to the following weblink for Rules and Regulations of B.Tech. program:

https://www.nitw.ac.in/media/uploads/2021/08/27/btech_rules-and-regulations-2021-22.pdf

PROGRAM EDUCATIONAL OBJECTIVES

PEO1	Analyze, plan and apply the acquired knowledge in basic sciences and mathematics in solving indigenously the IC requirements of the mankind with technical, economic, environmental and social contexts.
PEO2	Design, build and test analog and digital electronic systems for given specifications
PEO3	Architect miniaturized, efficient, high speed Integrated Circuits meeting modern communication system challenges.
PEO4	Work in a team using technical know-how, common tools and environments to achieve project objectives.
PEO5	Communicate effectively, demonstrate leadership qualities and exhibit professional conduct in their career.
PEO6	Engage in lifelong learning, career enhancement and adapt to changing professional and societal needs

Program Articulation Matrix

Mapping of Mission statements with program educational objectives

Mission Statement	PEO1	PEO2	PEO3	PEO4	PEO5	PEO6
MS1	3	3	2	1	1	3
MS2	1	2	1	3	3	2
MS3	1	2	1	3	3	2
MS4	1	2	2	3	1	1

1-Slightly, 2-Moderately, 3-Substantially.

Department of Electronics and Communication Engineering

PROGRAM OUTCOMES

PO1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and IC design and technology concepts towards modelling and prototyping Integrated systems.
PO2	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.
PO3	Design/development of solutions: Design methodology to offer hardware solutions to public health, safety and agriculture, consumer electronics along with cultural, societal, and environmental considerations.
PO4	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.
PO5	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.
PO6	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.
PO7	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.
PO8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
PO10	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.
PO11	Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply the set one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	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 (PSOs)

PSO1	Analyze and design Integrated Circuits & electronic systems to enhance the quality of human life
PSO2	Develop innovative and environment-conscious technologies to sustain human life

Mapping of Program Outcomes with Program Educational Objectives

PEO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PEO1	3	1	1	1	1	1	1	2	1	1	1	1
PEO2	2	3	3	3	1	1	1	1	2	1	1	1
PEO3	1	2	1	1	3	3	3	1	1	1	1	2
PEO4	1	1	3	1	1	1	1	3	3	3	1	1
PEO5	1	1	1	1	1	1	1	3	3	2	2	3
PEO6	2	1	1	1	2	2	2	3	2	2	3	3

SCHEME OF INSTRUCTION

B.Tech. Electronics and Communication Engineering (VLSI Design and Technology) - Course Structure

1st Semester

S. No	Course Code*	Course Title	L	T	P	Credits	Cat. Code
1	MA134	Matrix Theory, Calculus and Ordinary Differential Equations	3	0	0	3	BSC
2	HS132	English for Technical Communication	2	0	2	3	HSC
3	PH133	Engineering Physics	3	0	0	3	BSC
4	EV101	Electronic Devices	3	0	0	3	PCC
5	EE134	Network Theory	2	0	0	2	ESC
6	EV103	DIY - Electronics Lab	0	1	2	2	PCC
7	MA144	Problem Solving and Computer Programming	3	0	2	4	ESC
8	IC001	Induction Programme*				0	MNC
9	IC101	Extra Academic Activity-I *	0	0	2	0	MNC
		Total				**20**	

* MNC weblink: https://www.nitw.ac.in/media/uploads/2021/10/22/mnc_1st-year.pdf

2nd Semester

S.No	Course Code*	Course Title	L	T	P	Credits	Cat. Code
1	MA184	Integral Calculus and Laplace Transforms	3	0	0	3	BSC
2	CS182	Data Structures	3	0	2	4	ESC
3	CY186	Engineering Chemistry	3	0	0	3	BSC
4	EV151	Analog Circuit Design	3	0	0	3	PCC
5	EV152	Electronic Circuits Design lab	0	1	2	2	PCC
6	EC153	Joy of Electronics	0	0	2	1	ESC
7	EV154	Python for circuit simulation	0	1	2	2	ESC
8	IC151	Extra Academic Activity-II *	0	0	2	0	MNC
		Total				18	

* MNC weblink: https://www.nitw.ac.in/media/uploads/2021/10/22/mnc_1st-year.pdf

Note: BSC - Basic Science Courses
ESC - Engineering Science Courses
PCC - Professional Core Courses
PEC - Professional Elective Courses
OEC - Open Elective Courses
HSC - Humanities and Social Science Courses
MNC - Mandatory Non-credit Courses

SCHEME OF INSTRUCTION
B.Tech. Electronics and Communication Engineering (VLSI Design and Technology) - Course Structure
3rd Semester

S.No	Course Code*	Course Title	L	T	P	Credits	Cat. Code
1	MA234	Complex Variables and Special Functions	3	0	0	3	BSC
2	EE234	Control Systems Engineering	3	0	0	3	ESC
3	EC201	Digital Circuit Design	3	0	0	3	PCC
4	EV202	Signals and Systems	3	0	2	4	PCC
5	EV203	VLSI Technology	3	0	0	3	PCC
6	EC204	Introduction to Artificial Intelligence and Machine Learning	3	0	0	3	ESC
7	EC205	Digital Circuit Design Lab	0	1	2	2	PCC
8	EV206	Design Thinking Lab	0	1	2	2	ESC
9	IC2XX	Mandatory Non-credit Course*	1	0	0	0	MNC
		Total				23	

* MNC weblink:https://www.nitw.ac.in/media/uploads/2021/10/22/mnc_2nd-year.pdf

4th Semester

S.No	Course Code*	Course Title	L	T	P	Credits	Cat. Code
1	EC251	Linear IC Applications	3	0	0	3	PCC
2	EV252	CMOS Analog IC Design	3	0	0	3	PCC
3	EC253	Electromagnetic Waves and Fields	3	0	0	3	PCC
4	EV254	CMOS Digital IC Design	3	0	0	3	PCC
5	EC255	Probability Theory and Stochastic Processes	3	0	2	4	PCC
6	EV256	CMOS Analog IC Design Lab	0	1	2	2	PCC
7	EV257	CMOS Digital IC Design Lab	0	1	2	2	PCC
8	BT281	Design Principles Living Systems	2	0	0	2	ESC
		Total				22	

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SCHEME OF INSTRUCTION
B.Tech. Electronics and Communication Engineering (VLSI Design and Technology) - Course Structure

5th Semester

S.No	Course Code*	Course Title	L	T	P	Credits	Cat. Code
1	EC301	Digital Signal Processing	3	0	0	3	PCC
2	EV302	Pulse and Switching Circuits	3	0	0	3	PCC
3	EV303	Mixed Signal Circuits	3	0	0	3	PCC
4	EC304	Advanced Microcontrollers	3	0	0	3	PCC
5	EV305	Mixed Signal Circuits Lab	0	1	2	2	PCC
6	EC306	Microcontrollers Lab	0	1	2	2	PCC
7		Dept. Elective -I	3	0	0	3	PEC
8	SM344	Industrial Systems and Management	3	0	0	3	HSC
9	IC3XX	Mandatory Non-credit Course*	1	0	0	0	MNC
		Total				22	

* MNC weblink: https://www.nitw.ac.in/media/uploads/2021/10/22/mnc_3rd-year.pdf

6th Semester

S.No	Course Code*	Course Title	L	T	P	Credits	Cat. Code
1	EV351	Analog and Digital Communications	3	0	2	4	PCC
2	EV352	VLSI Verification and Testing	3	0	0	3	PCC
3	EV353	VLSI Verification and Testing Lab	0	1	2	2	PCC
4	EC354	Embedded and Real Time Operating Systems	3	0	0	3	PCC
5	EC356	Innovation and Start-up Activity	0	1	2	2	ESC
6		Dept. Elective -II	3	0	0	3	PEC
7		Dept. Elective -III	3	0	0	3	PEC
8		Open Elective -I#	3	0	0	3	OEC
		Total				23	

OEC weblink: https://www.nitw.ac.in/media/uploads/2021/10/22/open-elective-1_vi-sem.pdf

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SCHEME OF INSTRUCTION

B.Tech. Electronics and Communication Engineering (VLSI Design and Technology) - Course Structure

7th Semester

S.No	Course Code*	Course Title	L	T	P	Credits	Cat. Code
1	EV401	Semiconductor Materials Synthesis and Characterization	3	0	0	3	PCC
2	EV402	Semiconductor Device Characterization Lab	0	1	2	2	PCC
3	EV403	Data Communication Networks	2	0	0	2	PCC
4		Dept. Elective -IV	3	0	0	3	PEC
5		Dept. Elective -V	3	0	0	3	PEC
6		Open Elective -II	3	0	0	3	OEC
7	EV404	Low Power IC Design Lab	0	1	2	2	PCC
8	EV430	Design Project	0	0	2	1	PW
9	EV449	Summer Internship /EPICS	0	1	2	2	PCC
		Total				21	

OEC weblink: https://www.nitw.ac.in/media/uploads/2021/10/22/open-elective-2_vii-sem.pdf

8th Semester

S.No	Course Code*	Course Title	L	T	P	Credits	Cat. Code
1		Dept. Elective -VI	3	0	0	3	PEC
2		Dept. Elective -VII	3	0	0	3	PEC
3	EV499	Project Work@	0	0	8	4	PW
4							
5							
6							
7							
8							
		Total				10	

@ NOTE: Refer to the following link for the guidelines to prepare dissertation report:

https://www.nitw.ac.in/media/uploads/2021/08/27/ug_project-report-format_55vW5pL.pdf

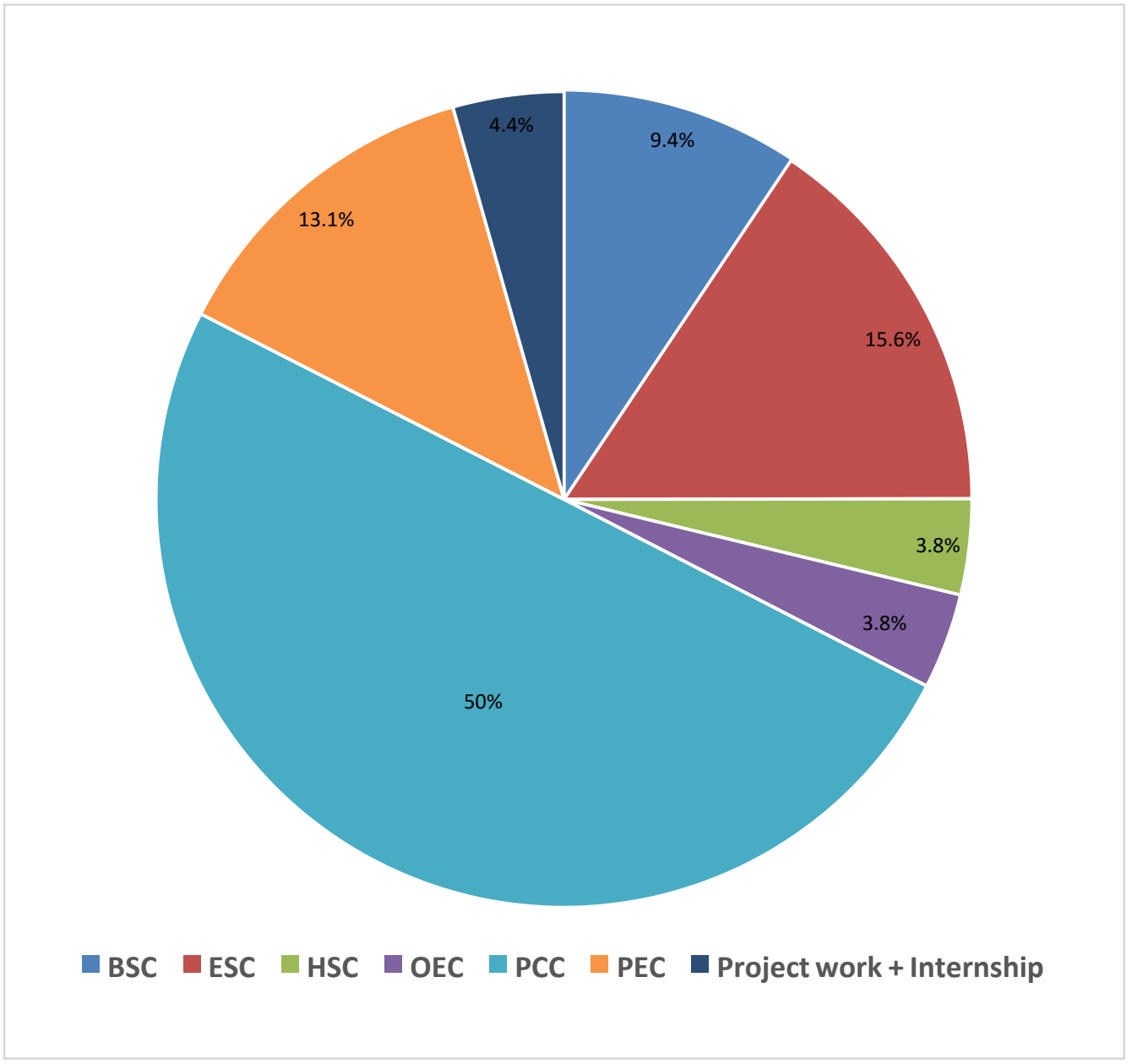
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MNC - Mandatory Non-credit Courses

Special Notes/Instructions:

The grade of summer internship / EPICS taken up during summer after IV semester or VI semester, will be reflected in the grade sheet of VII semester.

Semester wise Curriculum Components

Semester / Cat Code	I	II	III	IV	V	VI	VII	VIII	Credits offered
BSC	6	6	3						**15**
ESC	6	7	8	2		2			**25**
HSC	3				3				**6**
OEC						3	3		**6**
PCC	5	5	12	20	16	12	9		**79**
PEC					3	6	6	6	**21**
Project work							1	4	**5**
Internship							2		**2**
Total	20	18	23	22	22	23	21	10	**159**



Program Elective Courses

Semester	Elective Number	Course Code*	Course Title
V	I	EC315	Low Power VLSI
		EC316	Computer Architectures
		EV317	Semiconductor Device Modeling
		EV318	Flexible Electronics
VI	II	EC365	RFIC Design
		EV366	Devices for Microwave Engineering
		EV367	Antennas
		EV368	Semiconductor Optoelectronics
VII	III	EC415	Electronic Packaging
		EC417	Computer Vision
		EV418	VLSI Interconnects
		EV419	On Chip Sensors and Interfacing Circuits
VII	IV	EC419	FPGA Design
		EC421	Optimization Techniques
		EV422	Nanoelectronics
		EV423	Heterojunction Device Physics
VII	V	EC424	IPR and Cyber Laws
		EC425	Cryptography and Network Security
		EV426	ASIC Design
		EV427	Reliability of VLSI Systems
VIII	VI	EC466	5G Communications and MIMO
		EC468	Hardware-Software Co-Design
		EV469	High Speed Interfacing Circuits
		EV470	Introduction to Quantum Computing
VIII	VII	EC469	Intelligent CAD
		EC472	Cloud Computing
		EV473	MEMS & NEMS
		EV474	Power Management IC design

SYLLABI

1st Semester

Course Code: MA134	MATRIX THEORY, CALCULUS AND ORDINARY DIFFERENTIAL EQUATIONS	Credits 3-0-0: 3

Pre-Requisites: NIL

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

CO1	Solve the consistent system of linear equations
CO2	Apply orthogonal and congruent transformations to a quadratic form
CO3	Find the maxima and minima of multivariable functions
CO4	Solve arbitrary order linear differential equations with constant coefficients
CO5	Apply the concepts in solving physical problems arising in engineering

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1									2	1
CO2	3	3	2	1									2	1
CO3	3	3	2	1									2	1
CO4	3	3	2	1									2	1
CO5	3	3	2	1									2	1

Syllabus:

Matrix Theory: Linear dependence and independence of vectors; Rank of a matrix; Consistency Of The System Of Linear Equations; Eigenvalues and eigen vectors of a Matrix; Caley- Hamilton theorem and its applications; Reduction to diagonal form; Reduction of a quadratic form to canonical form - orthogonal transformation and congruent transformation; Properties of complex matrices - Hermitian, skew-Hermitian and Unitary matrices

Differential Calculus: Taylor's theorem with remainders; Taylor's and Maclaurin's expansions; Asymptotes; Curvature; Curve tracing; Functions of several variables - partial differentiation; total differentiation; Euler's theorem and generalization; Change of variables - Jacobians; maxima and minima of functions of several variables (2 and 3 variables) - Lagrange's method of multipliers

Ordinary Differential Equations: Geometric interpretation of solutions of first order ODE $y' = f(x, y)$; Exact differential equations; integrating factors; orthogonal trajectories; Higher order linear differential equations with constant coefficients - homogeneous and non- homogeneous; Euler and Cauchy's differential equations; Method of variation of parameters; System of linear differential equations; applications in physical problems – forced oscillations, electric circuits, etc.

Learning Resources:

Text Books:

1. Advanced Engineering Mathematics, **R. K. Jain and S. R. K. Iyengar**, Narosa Publishing House, 2019, Fifth Edition
2. Advanced Engineering Mathematics, **Erwin Kreyszig**, John Wiley and Sons, 2015, 10thEdition
3. Calculus and Analytic Geometry, **George B.Thomas and Ross L. Finney**,Pearson,2020,Ninth Edition

Reference Books:

1. Advanced Engineering Mathematics, **Dennis G. Zill**, Jones & Bartlett Learning, 2018, SixthEdition
2. Higher Engineering Mathematics, **B. S. Grewal**, Khanna Publishers, 2012, Forty-secondEdition

Course code: HS132	ENGLISH FOR TECHNICAL COMMUNICATION	Credits 2-0-2: 3

Pre-requisites: Nil

Course outcomes: After the completion of the course the student will be able to:

CO1	Understand basic grammar principles
CO2	Write clear and coherent passages
CO3	Write effective letters for job application and complaints
CO4	Prepare technical reports and interpret graphs
CO5	Enhance reading comprehension
CO6	Comprehend English speech sound system, stress and intonation

Course articulation matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-	-	-	-	-	-	-	-	2	-	3	1	-
CO2	-	-	-	-	-	-	-	-	-	3	-	3	1	-
CO3	-	-	-	-	-	-	-	-	-	3	-	3	1	-
CO4	-	-	-	-	-	-	-	-	-	3	-	3	1	-
CO5	-	-	-	-	-	-	-	-	-	3	2	3	1	-
CO6	-	-	-	-	-	-	-	-	-	3	2	3	1	-

Syllabus:

1. **Grammar Principles** (Correction of sentences, Concord) and Vocabulary Building (synonyms and antonyms): Idioms and Phrasal verbs--patterns of use and suggestionsfor effective employment in varied contexts
2. **Effective Sentence Construction** - strategies for bringing variety and clarity in sentences- removing ambiguity - editing long sentences for brevity and clarity
3. **Reported speech;-**contexts for use of reported speech - its impact on audiences and readers- active and passive voice- reasons for preference for passive voice in scientific English-
4. **Paragraph-writing:** Definition of paragraph and types- features of a good paragraph - unity of theme- coherence- linking devices- direction- patterns of development.
5. **Note-making** - definition- the need for note-making - its benefits - various note formats- like tree diagram, block or list notes, tables, etc.
6. **Letter-Writing:** Its importance in the context of other channels of communication- qualities of effective letters-types -personal, official, letters for various purposes- emphasis on letter of application for jobs - cover letter and resume types -examples and exercises
7. **Reading techniques:** Definition- Skills and sub-skills of reading- Skimming and Scanning - their uses and purposes- examples and exercises.
8. **Reading Comprehension** - reading silently and with understanding- process of comprehension- types of comprehension questions. (technical paper reading, patents)
9. **Features of Technical English** - description of technical objects and process- Report- Writing- definition- purpose -types- structure- formal and informal reports- stages in

developing report- proposal, progress and final reports-examples and exercises.

10. **Book Reviews**- Oral and written review of a chosen novel/play/movie- focus on appropriate vocabulary and structure - language items like special vocabulary and idioms used

Language laboratory:

1. **English Sound System** -vowels, consonants, Diphthongs, phonetic symbols- using dictionary to decode phonetic transcription-- Received Pronunciation, its value andrelevance- transcriptionof exercises-
2. **Stress and Intonation** –word and sentence stress - their role and importance in spoken English
3. **Intonation in spoken English** -definition, patterns of intonation- –falling, rising, etc.- use of intonation in daily life-exercises
4. **Introducing oneself in formal and social contexts**- Role plays.- their uses in developing fluency and communication in general.
5. **Oral presentation** - definition- occasions- structure- qualities of a good presentation with emphasis on body language and use of visual aids.
6. **Listening Comprehension** -Challenges in listening, good listening traits, some standard listening tests- practice and exercises.
7. **Debate/ Group Discussions**-concepts, types, Do‘s and don‘ts- intensive practice.

Text Books:

1. English for Engineers and Technologists (Combined edition, Vol. 1 and 2)OrientBlackswan2010.
2. Ashraf, M Rizvi. Effective Technical Communication. Tata McGraw-Hill,2006
3. Meenakshi Raman and Sangeetha Sharma. Technical Communication: Principlesand Practice 2nd Edition, Oxford University Press,2011

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

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc20_hs56/preview
2. https://nptel.ac.in/courses/109/106/109106094/
3. https://freevideolectures.com/course/3430/communication-skills
4. https://onlinecourses.swayam2.ac.in/cec21_lg13/preview

Course Code: PH133	ENGINEERING PHYSICS	Credits 3-0-0: 3

Pre-Requisites: None

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

CO1	Apply the concepts of wave and particle nature of matter and energy for solving problems radiant energy
CO2	Understand the physics of optical fibers, diode lasers and their applications in communication
CO3	Understand the basics of dielectric and functional materials and their applications in electrical engineering.
CO4	Comprehend the working of solar cells and emerging photovoltaic technologies
CO5	Understand temperature measurement using thermocouples and thermistors

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1									2	1
CO2	3	3	2	1									2	1
CO3	3	3	2	1									2	1
CO4	3	3	2	1									2	1
CO5	3	3	2	1									2	1

Syllabus:

Quantum Mechanics

Introduction to quantum theory, concepts and experiments led to the discovery, wave particle duality- Davisson-Germer experiment, Heisenberg uncertainty principle, Schrodinger time independent wave equation, the free particle problem-particle in an infinite and finite potential well, quantum mechanical tunneling - applications.

Electronic Materials

Dielectric Materials: Introduction to Dielectrics, Dielectric constant, polarizability, properties and types of insulating materials, polarization mechanisms in dielectrics (Qualitative), frequency and temperature dependence of polarization, dielectric loss, Clausius-Mossotti equation (qualitative), dielectric breakdown, applications in electrical engineering (electrolytic capacitor)**.**

Piezoelectric/Ferroelectric materials: Properties, production and detection of ultrasonic, applications inelectrical engineering.

Functional Materials: Fiber reinforced plastics, fiber reinforced metals, surface acoustic wave materials, high temperature materials and smart materials, properties and applications.

Optical Fibers and Devices

Principle and working of optical Fiber, structure, Classification and advantages of optical fiber, Light guiding mechanism in Optical Fibers -Numerical Aperture, Dielectric Slab wave Guide and Modes, Maxwell‘s Equations-Waveguide Equations and solutions (qualitative) under weekly guiding approximation -Modes in Step-Index fibers-LP Modes and their designation-Signal Degradation in optical fibers-Attenuation: Absorption-Scattering-bending-and Core-Cladding losses, Material, Waveguide, Inter and intra modal Dispersions

Light Sources: Basics of Semiconductor Physics-PN Junctions-LEDs and LED Structures-Quantum efficiency and LED Power and modulation of LED; Laser Diodes - Laser Diode Rate

Equations and Quantum Efficiency (qualitative treatment).

Solar Cells

Solar spectrum, photovoltaic effect, structure and working principle of solar cell, I-V characteristics, power conversion efficiency, materials for PV, emerging PV technologies for alternative energy devices**.**

Thermal Physics

Thermo electric laws - Seebeck effect, Peltier effect, Thompson effect, Thermocouples – types, characteristics and laws, Thermistors, Resistance Temperature Detector

Learning Resources

Text Books:

1. Fundamentals of Physics by Halliday, Resnic and Walker, John Wiley, 10thEdition,2013.
2. Concepts of Modern Physics by Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury, McGraw Hill Publications, Seventhedition,2017.
3. Optical Fiber Communications, by Gerd Keiser, McGraw Hill Education, 5th Edition,2017.

Reference Books:

1. Optics by Ajoy K. Ghatak,Tata McGraw Hill, Sixth Edition,2017
2. Understanding Lasers An Entry-Level Guide, by Jeff Hecht, Wiley Publications, Fourth edition,2018.
3. A Text Book of Engineering Physics by M.N. Avadhanulu, P.G. Khirsagar, 11th Edition, 2018.
4. University Physics with modern physics by Hugh D. Young, Roger A. Freedman Pearson 14th Education,2017.

Online Resources:

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

Course Code: EV 101	ELECTRONIC DEVICES	Credits 3-0-0: 3

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

CO1	Understand the semiconductor device physics
CO2	Understand the principle behind the PN junctions
CO3	Analyze the configurations of BJT/MOSFET
CO4	Create the BJT/MOSFET model for low and high frequency

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2								1	2	2	
CO2	2	3	2								1	2	2	
CO3	2	3	2	2					1		1	2	2	
CO4	2	3	2	2					1		1	2	2	

Syllabus:

Introduction to Semiconductor Physics: Review of Quantum Mechanics, Electrons in periodic Lattices, E-k diagrams. Energy bands, intrinsic and extrinsic semiconductor, direct and indirect bandgap semiconductors, elemental and compound semiconductor.

Carrier transport: Diffusion current, drift current, hall effect, mobility and resistivity; design of resistors, Generation and recombination of carriers; Poisson and continuity equation.

P-N junction characteristics, I-V characteristics, and small signal switching models; Avalanche breakdown, Zener diode, Schottky diode, Tunnel Diode, IMPATT Diode, Gunn Diode, Narrow base diode.

BJT: Structure, operation, I-V characteristics, Ebers-Moll Model, CE, CB, CC Configurations, large and small signal models.

MOSFET: MOS capacitor, C-V characteristics, MOSFET-Structure, operation, I-V characteristics, CS, CG, CD configurations, large signal and small signal models, CMOS technology.

Learning Resources:

Text Books:

1. Solid State Electronic Devices, B. G. Streetman, and S. K. Banerjee, Pearson, 7th edition, 2018.
2. Semiconductor Physics and Devices, D. Neamen, and D. Biswas, McGraw-Hill Education, 4th edition, 2017.
3. Fundamentals of Microelectronics, B. Razavi, Wiley, 3rd Edition, 2021.
4. Semiconductor Device Fundamentals, R. F. Pierret, Pearson, 1st Edition, 2006.

Reference Books:

1. Physics of Semiconductor Devices, S. M. Sze and K. N. Kwok, John Wiley & Sons, 3rd edition, 2006.
2. Electronic Devices and Circuit Theory, Robert L Boylestad and Louis Nashelsky, Pearson, 11th Edition, 2018.
3. Electronics Devices and Circuits, Jacob Millman and Christos Halkias, Tata McGraw Hill, 4th Edition, 2015.

Online Resources:

1. https://nptel.ac.in/courses/117106091

Course Code: EE133	Network Theory	Credits 2-0-0 :2

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

CO1	Simplify DC networks and analyze them using loop and node equations and determine the dual of a given network
CO2	Analyze magnetic circuits, and electric circuits with sinusoidal excitation along with the phenomenon of resonance
CO3	Formulate the dynamic equations of electric circuits using differential equations and simplify their solutions using Laplace.
CO4	Simplify the analysis of electric circuits using network theorems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2						1			1	1	1
CO2	2	1	2						1			1	1	1
CO3	2	1	2						1			1	1	1
CO4	2	1	2						1			1	1	1

Syllabus:

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

Network Theorems: Superposition theorem, Thevenin‘s theorem, Norton‘s theorem, Maximum powertransfer theorem, Millman‘s theorem, Tellegen‘s theorem.

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. Introduction to band pass, low pass, high pass and band reject filters.

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.

Learning Resources:

Text Books:

1. Network Analysis, M.E. Van Valken Burg, PHI, 3rdedition, 2015.
2. Fundamentals of Electric Circuits, Charles K Alexander and Matthew N Sadiku, Mc Graw Hill, 7th Edition, 2021
3. Engineering Circuit Analysis, William H. Hayt, Jack Kemmerly, Steven M. Durbin, Tata McGraw-Hill,8thEdition, 2013.

Reference Books:

1. A Course in Electrical Circuit Analysis, M.L.Soni and J.C. Gupta, Dhanpat Rai & Co. (P),2001.
2. Network Analysis, G.K Mittal & Ravi Mittal, Khanna Publications, 14th Edition, 2003.
3. Engineering Network Analysis and Filter Design, Gopal G Bhise, Prem R Chadha &Durgesh C. Kulshreshtha Gopal, Umesh Publications, 2012.
4. Electrical Engineering Fundamentals, Vincent Del Toro, PHI, 2nd Edition, 2003.
5. Basic Electrical Engineering, V N Mittle, TMH, Edition, 2000.
6. Linear circuit Analysis, De Carlo & Lin: Oxford University Press, 2nd Edition, 2010.

Online Resources:

1. https://nptel.ac.in/courses/108/104/108104139/
2. https://nptel.ac.in/courses/108/102/108102097/
3. https://nptel.ac.in/courses/108/105/108105155/

Course code: EV103	DIY Electronics Lab	Credits 0–1–2: 2

Course Outcomes: After completion of the course student will be able to:

CO1	Identify the electronic components
CO2	Understand the working of electronics lab equipment
CO3	Plot the characteristics of diodes and transistors to understand their behavior using experiment/simulation
CO4	Implement an Do it Yourself (DIY) electronics project

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2	-	-	-	-	-	2	1	-	2	1	1
CO2	2	3	2	-	-	-	-	-	2	1	-	2	1	1
CO3	2	3	2	2	-	-	-	-	2	1	-	2	1	1
CO4	2	3	2	2	3	2	-	-	2	1	2	2	2	2

List of Experiments:

1. Study of components (R, L, C, Diodes, Transistors, etc)
2. Study of Instruments (CRO, Signal Generator, DC Power Supply, Voltmeter, Ammeter, DMM etc)
3. SPICE simulations for Diode circuits and BJT/MOSFET characteristics
4. V-I Characteristics of Diodes
5. BJT Characteristics (CE, CB, CC)
6. MOSFET Characteristics (CS, CG, CD)
7. DIY Electronics Project

Learning Resources:

Text Books:

1. Solid State Electronic Devices, B. G. Streetman, and S. K. Banerjee, Pearson, 7th edition, 2018.
2. Semiconductor Physics and Devices, D. Neamen, and D. Biswas, McGraw-Hill Education, 4th edition, 2017.
3. Fundamentals of Microelectronics, B. Razavi, Wiley, 3rd Edition, 2021.
4. SPICE, G. W. Roberts, A. S. Sedra, Oxford University Press, 2nd Edition, 1997.

Reference Books:

1. Physics of Semiconductor Devices, S. M. Sze and K. N. Kwok, John Wiley & Sons, 3rd edition, 2006.
2. Electronics Devices and Circuits, Jacob Millman and Christos Halkias, Tata McGraw Hill, 4th Edition, 2015.
3. Semiconductor Device Fundamentals, R. F. Pierret, Pearson, 1st Edition, 2006.

Online Resources:

1. https://nptel.ac.in/courses/117106091

Course Code: MA144	PROBLEM SOLVING AND COMPUTER PROGRAMMING	Credits 3-0-2: 4

Pre-Requisites: NIL

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

CO1	Design algorithms for solving simple mathematical problems including computing, searching and sorting
CO2	Compare and contrast algorithms in terms of space and time complexity to solve simple mathematical problems
CO3	Explore the internals of computing systems to suitably develop efficient algorithms
CO4	Examine the suitability of data types and structures to solve specific problems
CO5	Apply control structures to develop modular programs to solve mathematical problems
CO6	Apply object oriented features in developing programs to solve real world problems

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	-	2	-	-	2	-	-	-	-	-
CO2	3	3	2	2	-	2	-	2	2	-	-	-	-	-
CO3	3	3	2	2	-	-	-	2	2	-	-	-	-	-
CO4	2	3	2	1	-	2	-	-	2	-	-	-	-	-
CO5	2	3	2	2	-	2	-	-	2	-	-	-	-	-
CO6	2	3	2	2	-	2	-	-	2	-	-	-	-	-

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 overloading, 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. Problem Solving with C++, **Walter Savitch**, Pearson, 2014, Ninth Edition
2. Big C++, **Cay Horstmann**, Wiley, 2009, Second Edition

ReferenceBooks:

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

Online Resources:

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

Course Code: IC001	Induction Programme *	Credits 0-0-0:0

Pre-Requisites:

Course Outcomes:

CO1	
CO2	
CO3	
CO4	
CO5	
CO6	

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1														
CO2														
CO3														
CO4														
CO5														
CO6														

Syllabus:

Learning Resources:

Text Books:

ReferenceBooks:

Online Resources:

Course Code: IC101	Extra Academic Activity- I *	Credits 0-0-0:0

Pre-Requisites:

Course Outcomes:

CO1	
CO2	
CO3	
CO4	
CO5	
CO6	

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1														
CO2														
CO3														
CO4														
CO5														
CO6														

Syllabus:

Learning Resources:

Text Books:

ReferenceBooks:

Online Resources:

2nd Semester

Course Code: MA184	INTEGRAL CALCULUS AND LAPLACE TRANSFORMS	Credits 3-0-0: 3

Pre-Requisites: MA134

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

CO1	Analyze improper integrals
CO2	Evaluate multiple integrals in various coordinate systems
CO3	Apply the concepts of gradient, divergence and curl to formulate engineering problems
CO4	Convert line integrals into surface integrals and surface integrals into volume integrals
CO5	Apply Laplace transforms to solve physical problems arising in engineering

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1									2	1
CO2	3	3	2	1									2	1
CO3	3	3	2	1									2	1
CO4	3	3	2	1									2	1
CO5	3	3	2	1									2	1

Syllabus:

Integral Calculus: Convergence of improper integrals; Beta and Gamma integrals; Differentiation under integral sign; Double and Triple integrals – computation of surface areas and volumes; 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; Line and Surface 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 function, impulse function, periodic function; Convolution theorem; Applications of Laplace transforms-solving certain initial value problems, solving system of linear differentialequations, finding responses of systems to various inputs viz. sinusoidal inputs acting over a time interval, rectangular waves, impulses etc.

Text Books:

1. Advanced Engineering Mathematics, **R. K. Jain and S. R. K. Iyengar**, Narosa Publishing House, 2016, Fifth Edition
2. Advanced Engineering Mathematics, **Erwin Kreyszig**, John Wiley and Sons, 2015, EighthEdition
3. Calculus and Analytic Geometry, **George B. Thomas and Ross L. Finney**, Pearson, 2020,NinthEdition

Reference Books:

1. Advanced Engineering Mathematics, **Dennis G. Zill**, Jones & Bartlett Learning, 2018, SixthEdition
2. Higher Engineering Mathematics, **B. S. Grewal**, Khanna Publishers, 2012, Forty-secondEdition

Course Code: CS182	DATA STRUCTURES	Credits 3–0–2: 4

Prerequisites: Problem Solving and Computer Programming

Course Outcomes: After completion of the course student will be able to:

CO1	Understand the basic techniques of algorithm analysis and assess how the choice of data structures impact the performance of programs.
CO2	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.
CO3	Implement graphs as adjacency matrix, adjacency list, Searching technique - Breadth First Search and Depth First Search.
CO4	Analyze, evaluate and choose appropriate data structures and algorithms for a specific application.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	-		
CO2	3	-	-	-	-	-	-	-	-	-	-	2		
CO3	2	-	-	-	-	-	-	-	2	-	-	-		
CO4	3	-	-	-	-	-	-	-	2	-	-	1		

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.

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 inlinear 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 runsin 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 runsin linear time and the *dequeue* operation runs in constant time.
10. Write programs to implement the following datastructures:
    (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 orderand 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.

Text Books:

1. Thomas H. Cormen, Charles E Leiserson, Ronald L. Rivest and Clifford Stein, I*ntroduction toAlgorithms*, PHI, 2nd Edition, 2009.
2. Mark Allen Weiss, *Data Structures and Algorithm Analysis in C++*, Third Edition, PearsonEducation,2006
3. Ellis Horowitz, Sartaj Sahni and Sanguthevar Rajasekaran, *Fundamentals of Computer Algorithms*, Universities Press, 2nd Edition, 2011.
4. Michael T.Goodrich and Roberto Tamassia, *Algorithm Design: Foundations, Analysis andInternet Examples*, Wiley India, 2nd Edition, 2006.

Online Resources:

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/

Course Code: CY186	ENGINEERING CHEMISTRY	Credits 3-0-0: 3

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

CO1	Understand the basic concept of physical chemistry and apply the concepts in developing batteries
CO2	Understand the chemistry involved in the synthesis and characterization of Nanomaterials and apply the knowledge in developing various electrical engineering materials
CO3	Understand the concepts of spectroscopy and apply the knowledge in characterizing the material using spectroscopic methods.
CO4	Apply the knowledge to protect different metals from corrosion
CO5	Apply the concepts learned in designing materials for green energy harvesting and storage to reduce the environmental pollution and develop greener methods to replace the existing non-eco-friendly process for industrial production of materials.

CO-PO/PSO mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2		2			3	2				2	1	
CO2	3	2		2			1					2	1	
CO3	2	1		1								1	1	
CO4	3	2		1			2					1	1	
CO5	3	3		3			3	3				3	1	

Syllabus:

1. **Thermochemistry:** Heat of Reaction, Types of Heats of Reaction, Kirchhoff's Equation,Laws of Thermochemistry, Bond Energy and Bond Enthalpy.
2. **Nanomaterials and Engineering Applications:** Introduction, classification, properties, Nanotechnology applications, Material self-assembly, Molecular vs material self-assembly, synthesis - top down and bottom up, synthesis, properties & potential applications of carbon nanotubes, fullerenesand grapheme, Nano catalysis
3. **Spectroscopic Methods of Analysis:** UV-Vis spectroscopy, Infrared spectroscopy, NMR spectroscopy
4. **Electrochemistry:** Electrical conductance, migration of ions, theories of ionization, redox potentials and Nernst's law and its applications.
5. **Batteries and Corrosion:** Batteries: Electrode potential, primary cell-Leclanche cell, Secondary cell - Lead-acid storage cell, Lithium ion battery, Methanol oxygen fuel cell.**Corrosion:** Introduction, Dry corrosion, Wet corrosion, Factors influencing the rate of corrosion — Temperature, pH and Dissolved oxygen, Corrosion prevention by Cathode protection.
6. **Engineering Materials:** Semiconductors, Insulators, Superconductors, Conducting

Polymers, LEDs, Liquid Crystals, **P**hotovoltaic cell, Materials used for fabric sensors, Organo Electronics, Molecular Switches, Chemical Sensors, and Transducers

7. **Green Chemistry:** Principles of Green Chemistry. Green methods in electronic production. Green Materials for Electronics and Advanced Technologies (Aluminium Borosilicate, Glass Iron Alloys Graphene Biomaterials). Electronic-Waste: Plastics in Electronic-Waste, Impact ofElectronic-Waste on Environmental Public Health.

Text Books:

1. A Text Book of Engineering Chemistry, Shashi Chawla, Danpathrao & Co. Publications, 6th India reprintedition,2017
2. Text Book of Engineering Chemistry, AshutoshKar, ED-Tech Publications, 2018

Reference Books:

1. Inorganic Chemistry, Huheey, Pearson Publications India, 4th edition 2006.
2. Molecular Quantum Mechanics, Peter Atkins, Oxford University Press, 5th edition 2012.
3. Advanced Organic Chemistry: Reaction Mechanism and Structure, Jerry March, John Wiley Publications, 6th Edition,2007

Online Resources:

1. https://nptel.ac.in/courses/122/101/122101001/
2. https://nptel.ac.in/courses/122/106/122106028/
3. https://nptel.ac.in/courses/104/101/104101130/

Course Code: EV151	ANALOG CIRCUIT DESIGN	Credits 3-0-0: 3

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

CO1	Understand the working of Diode based circuits
CO2	Analyze the biasing of transistors
CO3	Design the amplifier for given specification
CO4	Apply feedback concept for design of amplifier and oscillators

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	3						1		1	2	2	
CO2	2	2	3	2	2				1		1	2	2	
CO3	2	2	3	2	2				1		1	2	2	
CO4	2	2	3	2	2				1		1	2	2	

Syllabus:

Diode Circuits: Rectifiers, C, L, LC, π filters, clippers, clampers, voltage regulators.

Amplifier: Basic concepts of Bipolar/MOS amplification, DC load line, stability, Operating point Analysis and Design, Single stage amplifier topologies Bipolar (CE, CB and CC) and MOS (CS, CG and CD). Cascode stages and current mirrors.

Frequency Response: Fundamental concepts, Bode rules, Miller theorem, Estimation of voltage gain, input resistance, output resistance. Low and high frequency response of CE/CS, CB/CG and CC/CD stages.

Feedback: Concept of feedback, positive & negative feedback, Voltage series, current series, voltage shunt, current shunt, effect of feedback on gain, bandwidth, input/output impedance, calculation with practical circuits, concept of stability, gain margin and phase margin.

Oscillators: Barkhausen criterion, RC oscillators (phase shift, Wien bridge), LC oscillators (Hartley, Colpitt, Clapp).

Learning Resources:

Text Books:

1. Fundamentals of Microelectronics, B. Razavi, Wiley, 3rd Edition, 2021.
2. Integrated Electronics, Jacob Millman, Christos C Halkias, Chetan D Parikh, Mc Graw Hill Education, 2nd Edition, 2017
3. Microelectronics Circuit Analysis and Design, Donald Neamen, McGraw Hill, 4thEdition, 2021
4. Electronic Devices and Circuits, David A Bell, Oxford University Press, 5th Edition, 2017.

Reference Books:

1. Electronic Devices and Circuit Theory, Robert L Boylestad and Louis Nashelsky, Pearson,11thEdition, 2015.
2. Microelectronic Circuit Design, Richard C Jaeger and Travis N Blalock, McGraw Hill, 6thEdition, 2022.
3. Microelectronic Circuits: Theory and Applications, Adel S Sedra, K C Smith and A N Chandorkar, OxfordUniversity Press, 7thEdition, 2017.

Online Resources:

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

Course Code: EV152	ELECTRONIC CIRCUITS DESIGN LABORATORY	Credits 0-1-2: 2

Course Outcomes: After completion of the course student will be able to:

CO1	Analyze the diode circuits
CO2	Design MOSFET based amplifiers
CO3	Evaluate the effect of feedback on performance of amplifiers & Oscillators
CO4	Design Diode and MOSFET circuits in SPICE

Course Articulation matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	3	2	-	1	-	-	-	2	-	-	2	1	1
CO2	1	3	2	1	1	-	-	-	2	-	-	2	1	1
CO3	1	3	2	1	1	-	-	-	2	-	-	2	1	1
CO4	1	3	2	1	1	-	-	-	2	-	-	2	1	1

LIST OF EXPERIMENTS:

1. Half Wave and Full Wave Rectifiers
2. Clippers and clampers
3. Zener Diode as Voltage Regulator
4. MOSFET Biasing Circuits
5. Single stage amplifier/Two stage amplifier
6. Voltage series feedback amplifier
7. Voltage shunt feedback amplifier
8. Current series feedback amplifier
9. Current shunt feedback amplifier
10. RC phase shift oscillator
11. LC oscillator
12. SPICE

simulationsLearning

Resources:

Text Books:

1. Fundamentals of Microelectronics, B. Razavi, Wiley, 3rd Edition, 2021.
2. Integrated Electronics, Jacob Millman, Christos C Halkias, Chetan D Parikh, Mc Graw Hill Education, 2nd Edition, 2017
3. Microelectronics Circuit Analysis and Design, Donald Neamen, McGraw Hill, 4thEdition, 2021
4. SPICE, G. W. Roberts, A. S. Sedra, Oxford University Press, 2nd Edition, 1997

Reference Books:

1. Electronic Devices and Circuit Theory, Robert L Boylestad and Louis Nashelsky, Pearson,11th Edition, 2015.
2. Microelectronic Circuit Design, Richard C Jaeger and Travis N Blalock, McGraw Hill, 6th Edition,2022.
3. Microelectronic Circuits: Theory and Applications, Adel S Sedra, K C Smith and A N Chandorkar, OxfordUniversity Press, 7th Edition, 2017.

Online Resources:

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

Course Code: EC153	JOY OF ELECTRONICS	Credits 0-0-2: 1

Pre-Requisites: NIL

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

CO1	Identify various electronics components with their specifications and measure them
CO2	Work with printed circuit boards and the tools and design simple circuits
CO3	Understand and operate different laboratory instruments, component testers
CO4	Work with various types of sensors and transducers
CO5	Work with different types of microcontrollers boards

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1						1					2		
CO2	2		2		2							2	2	2
CO3	1						1		2			2		
CO4			3					1	2	2	1	2	3	3
CO5			3		2				2	2	1	2	3	3

1 -Slightly; 2 -Moderately; 3 –Substantially

Syllabus:

1. Introduction to Resistors, inductors, Capacitors, Breadboards, PCBs, ICs, IC sockets,cables and connectors, Diodes, Transistors, FETs, 7-segmentdisplays
2. Soldering and de-soldering, Bread boarding, General purpose PCBs, PCB art work , Design of PCBs forsimple circuits, PCB Drillers, Hand tools
3. Common Instruments and their working: CROs, DSOs, DVMs, DMMs, Frequency counters, Waveformgenerators, working with power supplies, Assembling and Disassembling a gadget/ simple instrument
4. Component testers: Active & Passive components testing, IC testers,
5. Working with different types of sensors and components: Temperature, Moisture, Gas, Light, Ultrasonic, pH, Relays, IR, Accelerometers, DC motors, motor drivers, solar panels, smoke and Fire sensors, LCD and LED displays
6. Working with Microcontroller boards: Aurdino, RasberryPi
7. Training Workshops: Microcontrollers, Robotics, IoT, Machine learning, Computer vision, Drones
8. Take home project: LED Blink Pattern, Gas Sensing, Alcohol Sensing, Motor Operation by Timing, Fire Alarm, Burglar Alarm, Plant Moisture Monitoring, Android Controlled Caretc.,

Resources:

1. Lab charts/manuals
2. Equipment manuals
3. Datasheets
4. Internet resources

Course Code: EV154	PYTHON FOR CIRCUIT SIMULATION	Credits 0-1-2: 2

Pre-Requisites: EV101, EE1x1, EV151

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

CO1	Develop the application specific codes using python
CO2	Apply modular approach in python programs
CO3	Implement Digital logic gates using Python
CO4	Analyze electronic circuits using SPICE interface

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	2		2				2		1	1	1	
CO2	1	2	1		2				2		1	1	1	
CO3	2	2	2		2				2		2	1	2	
CO4	2	2	2	2	2				2		2	1	2	

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 Datastructures, 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

Pyspice, Numpy, Pandas, Data visualization libraries, Jupyter Notebook, Python IDEs

Exercise 1 Basics

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 - 2 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 – 3 Arrays

Find mean, median, mode for the given set of numbers in a list. Write a program to find common values between two arrays.
Write a program to count the numbers of characters in the string and store them in a dictionary data structure

Exercise – 4 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
Python program to split and join a string

Python Program to Sort Words in Alphabetic Order

Exercise -5 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 - 6 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 - 7 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- 8 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 – 9 Digital Logic
Write a program to implement Digital Logic Gates – AND, OR, NOT, EX-OR

Exercise-10 SPICE Interface
Write a program to design RLC circuit using SPICE interface.

Exercise-11 Device Characteristics
Write a program to find the diode V-I characteristics using SPICE interface. Write a program to find the transistor V-I characteristics using SPICE interface.

Exercise-12 Electronic Circuits
Write a program to design diode circuits (rectifier, clipper, clamper, regulator) using SPICE interface.
Write a program to design the FET based amplifier circuits using SPICE interface.

Text Books:
1. Python Programming: A Modern Approach, VamsiKurama,Pearson
2. Learning Python, Mark Lutz, Orielly

Reference Books:
1. Think Python, Allen Downey, Green TeaPress
2. Core Python Programming, W.Chun, Pearson
3. Introduction to Python, Kenneth A. Lambert, Cengage

Online Resources:
1. Website reference links

urse Code: IC151	Extra Academic Activity- II *	Credits 0-0-2:0

Pre-Requisites:

Course Outcomes:

CO1	
CO2	
CO3	
CO4	
CO5	
CO6	

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1														
CO2														
CO3														
CO4														
CO5														
CO6														

Syllabus:

ReferenceBooks:

Online Resources:

3rd Semester

Course Code: MA234	Complex Variables and Special Functions	Credits 3-0-0: 3

Pre-Requisites: 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	-	-	-	-	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

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 solutionsPower 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, 8th Edition,2017.
2. S.S. Sastry, *Introductory methods of Numerical Analysis*, PHI, 5th Edition 2012.
3. W.W. Bell, *Special Functions For Scientists and Engineers*, Dover Publications, 2004.
4. Erwin Kreyszig: *Advanced Engineering Mathematics*, John Wiley and Sons, 10th Edition, 2010.
5. B.S. Grewal: Higher Engineering Mathematics, Khanna Publications, 43th Edition, 2014.

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, 6th Edition, 2019

3. Complex variables and Applications: by R. V. Churchill, T. J. Brown & R. F. Verhey, McGraw Hill, 9th Edition, 2013

Course Code: EE234	Control Systems Engineering	Credits 3-0-0: 3

Pre-Requisites: Mathematics 1, 2 and 3

Course Outcomes:

CO-1	Understand and analyse electrical & electro-mechanical systems using transfer function approach
CO-2	Determine Transient and Steady State behavior of systems using standard test signals.
CO-3	Determine absolute and relative stability of dynamic systems using time & frequency domain analyses
CO-4	Design compensators for linear control systems to derive the specified steadystate and dynamic responses

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				3	2
CO-2	3	3	3	3	3				2				3	2
CO-3	3	3	3	3	3				2				3	2
CO-4	3	3	3	3	3				2				3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: System, control system, types of control systems, Transfer Function, open loop and closed loop systems, types of feedback, feedback and its effects.

Modelling of Physical Systems: Mathematical modelling of Electrical and Electro-mechanical elements, D.C. motors. Block diagram illustration.

Techniques to Develop Transfer Function of Systems: Introduction, Block diagram reduction technique and signal flow graph, Mason's gain formula.

Time Domain Analysis of Control Systems: Introduction- time domain indices, steady state error constants, concept of BIBO stability, absolute stability. Routh- Hurwitz Criterion.

Root Locus Techniques: Introduction, Root loci theory, Application to system stability analysis. Illustration of the effect of addition of zero and pole.

Frequency Domain **Analysis of Control Systems:** Introduction, Bode plots, Frequency domain indices, application of Bode plots, Polar plots. P, PI & PID controllers.

State-Space Representation of Dynamic Systems: State-Variables, State-Variable representation of Electrical Systems.

Learning Resources:

Text Books:

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

Reference Books:

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

Other Suggested Readings:

1. https://www.controleng.com/

Course Code: EC201	Digital Circuit Design	Credits 3-0-0: 3

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	-	-	-	-	-	-	-	-	1	2	1
CO-2	2	3	-	-	-	-	-	-	-	-	-	1	2	1
CO-3	-	2	-	-	-	-	-	-	-	-	-	1	2	1
CO-4	2	2	1	-	-	-	-	-	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. Jayaram Bhasker, Verilog Primer, 3rd edition, Prentice-Hall India, 1998.
4. Sameer Palnitkar, Verilog HDL: A guide to digital Design and Synthesis, 2nd edition, Pearson, 2003.

Reference Books:

1. John F Wakerly, Digital Design Principles and Practices, 3rd Edition, Prentice Hall India, 2001.
2. Franklin P. Processor, David E. Winkel, The Art of Digital Design: An Introduction to Top-Down Design, 2nd Edition, PTR Prentice Hall, 1987.

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: EV202	Signals and Systems	Credits 3-0-2: 4

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 signal and 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	-	-	-	-	-	-	-	-	-	-	-	2	-
CO-2	3	-	-	-	-	2	-	-	-	-	-	1	2	-
CO-3	3	-	-	-	-	-	-	-	-	-	-	-	2	-
CO-4	2	3	-	-	-	-	-	-	-	-	-	-	2	-
CO-5	2	3	-	-	-	3	-	-	-	-	-	1	2	-

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

Reference Books:

1. Simon Haykin, Barry van Veen, "Signals and Systems", John Wiley and Sons (Asia) Private Limited, 1998.
2. Robert A. Gabel, Richard A. Roberts, "Signals and Linear Systems", John Wiley and Sons, 1995.

Other Suggested Readings:

1. NPTEL Courses : https://nptel.ac.in/courses/10810410

Course Code: EV203	VLSI Technology	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

CO-1	Explain the unit fabrication process steps
CO-2	Explain the functions of packaging
CO-3	Analyze process yield and yield measurement for a process
CO-4	Propose the process flow for novel MOS devices
CO-5	Construct the circuit layout using the design rules

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	3	-	-	-	-	-	1	2	2	-
CO-2	2	2	1	1	1	-	-	-	-	-	1	2	2	-
CO-3	2	2	2	2	1	-	-	-	-	-	1	2	2	-
CO-4	3	3	3	3	2	-	-	-	-	-	1	2	2	1
CO-5	2	3	1	2	3	-	-	-	-	-	1	2	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Environment for VLSI Technology: Clean room and safety requirements. Wafer cleaning processes and wet chemical etching techniques.

Impurity incorporation: Solid State diffusion modelling and technology; Ion Implantation modelling, technology and damage annealing; characterization of Impurity profiles.

Oxidation: Kinetics of Silicon dioxide growth both for thick, thin and ultrathin films. Oxidation technologies in VLSI and ULSI; Characterization of oxide films; High k and low k dielectrics for ULSI.

Lithography: Photolithography, E-beam lithography and newer lithography techniques for VLSI/ULSI; Mask generation.

Chemical Vapor Deposition techniques: CVD techniques for deposition of polysilicon, silicon dioxide, silicon nitride and metal films; Epitaxial growth of silicon; modelling and technology.

Metal film deposition: Evaporation and sputtering techniques. Failure mechanisms in metal interconnects; multi-level metallization schemes. Plasma and Rapid Thermal Processing: PECVD, Plasma etching and RIE techniques; RTP techniques for annealing, growth and deposition of various films for use in ULSI.

Process integration for NMOS, CMOS and Bipolar circuits; Advanced MOS technologies

Learning Resources:

Text Books:

1. Plummer, J.D., Deal, M.D. and Griffin, P.B. Silicon VLSI Technology: Fundamentals, Practice and Modeling , , Prentice-Hall , 2000, 3rd Edition.
2. S.K. Gandhi, VLSI Fabrication principles, John Wiley and Sons, NY, 1994.

Reference Books:

1. S.M. Sze, VLSI technology, McGraw-Hill Book company, NY, 1988.

Other Suggested Readings:

1. NPTEL Courses

Course Code: EC204	Introduction to Artificial Intelligence and Machine Learning	Credits 3-0-0: 3

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	3	-	-	-	-	-	-	-	2	-	3	2	-	-
CO-2	3	2	-	2	3	-	-	-	2	-	3	2	2	-
CO-3	3	1	-	-	-	-	-	-	2	-	3	2	-	-
CO-4	3	3	2	3	3	-	-	-	2	-	3	2	2	-
CO-5	3	3	2	3	3	-	-	-	2	-	3	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.

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.Second Edition, 2003.

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: EC205	Digital Circuit Design Lab	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

CO-1	Develop data flow, behavioral 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	-	-	-	-	-	-	-	-	-	1	2
CO-2	-	2	3	-	-	-	-	-	-	-	-	-	1	2
CO-3	-	3	2	-	-	-	-	-	-	-	-	-	1	2
CO-4	-	3	2	-	-	-	-	-	-	-	-	2	1	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

LIST OF EXPERIMENTS:

List of Experiments:

1. Develop dataflow Verilog models for
   a) 2-to-4decoder
   b) 8-to-3encoder
   c) 4:1 mux
   d) fulladder/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, Sixth edition Pearson education
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, 4th edition, 2009.
5. Douglas Perry, ―VHDL‖, Tata McGraw Hill, 4th edition, 2002.

Reference Books:

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

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: EV206	Design Thinking Lab	Credits 0-1-2: 2

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 Every where – 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.

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. Design Thinking: A guide to creative problem solving for everyone, Andrew Pressman, Routledge Taylor and Francis group, 2019, 1st edition.
4. Engineering Design, George E. Dieter, Linda C. Schmidt, McGraw-Hill Education, 2019, 5th edition.
5. Product design and development, Ulrich, K., Eppinger, 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/

Course Code: IC2XX	Mandatory Non-credit Course*	Credits 1-0-0: 0

PreRequisites: None

Course Outcomes:

CO-1	
CO-2	
CO-3	
CO-4	
CO-5	

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	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Syllabus:

Learning Resources:

Text Books:

Reference Books:

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

4th Semester

Course Code: EC251	Linear IC applications	Credits 3-0-0: 3

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	-	-	-	-	-	-	-	-	-	-	-
CO-2	2	3	2	-	-	-	-	-	-	-	-	-	-	-
CO-3	1	2	2	-	-	-	-	-	-	-	-	-	-	-
CO-4	1	2	-	-	2	-	-	-	-	-	-	2	-	-

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, 5th Edition, Elsevier science, 2003
2. Sergio Franco, Design With Operational Amplifier And Analog Integrated Circuits, 4th Edition, TMH, 2017.
3. Roy Choudary D. and Shail B. Jain, Linear Integrated circuits, 4th Edition, New Age International

Publishers, 2017
4. Ramakant A. Gayakwad, Op-Amps and Linear Integrated Circuits, 4th Edition, PHI, 2015.

Reference Books:

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

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: EV252	CMOS Analog IC Design	Credits 3-0-0: 3

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Analysis of MOSFET small signal model: Effect of channel length modulation and back gate effect, evaluation of figure of merit for MOSFET under different biasing conditions.

Sources and references: Current sources and sinks, Basic current mirror, cascode current mirror, Wilson and Widlar current mirrors, voltage and current references.

CMOS amplifiers: Common source amplifier with different loads, CS stage with negative feedback, source follower, CG stage, Gain boosting techniques, Cascode topology.

Differential amplifier: Characterization of differential amplifier, concept of common mode rejection, small signal analysis of differential amplifier, differential amplifier with MOS loads.

Operational amplifier: Characteristics of ideal operational amplifier, constituents of op-amp, small signal analysis of 2 stage op-amp, stability challenges and solutions.

Learning Resources:

Text Books:

1. Behzad Razavi, Design of Analog CMOS Integrated Circuit, McGraw Hill Education, 2nd Edition 2017
2. Pr Gray and Rg Meyer, Analysis and Design of Analog Integrated Circuits, 6th Edition, Wiley, 2024.
3. Mohammed Ismail and Terri Fiez, Analog VLSI: Signal and Information Processing, McGrawHill, 1994.

Reference Books:

1. Geiger, Allen and Stradder, VLSI Design Techniques for Analog and Digital Circuits, Tata McGraw-Hill Education, 2010.

Other Suggested Readings:

1. NPTEL Courses (https://nptel.ac.in/courses/117101105)

Course Code: EC253	Electromagnetic Fields and Waves	Credits 3-0-0: 3

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	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2	2	2	-	-	-	2	-	-	-	-	-	-	-	-
CO-3	2	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-4	3	-	-	-	-	2	-	-	-	-	-	-	-	-

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, 2015 2nd Edition.
2. John D.Kraus, Electromagnetics, McGraw Hill Book Co., 5th Edition, 1998.

Reference Books:

1. Engineering Electromagnetics – Nathan Ida, 2ndEd., 2005, Springer (India) Pvt. Ltd., New Delhi.
2. Engineering Electromagnetics – William H. Hayt Jr. and John A. Buck, 8th Ed., McGrawHill,2017
3. Principles of Electromagnetics – Matthew N.O. Sadiku and S.V. Kulkarni, 6th Ed., Oxford University Press, Asian Edition, 2015.

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: EV254	CMOS Digital IC Design	Credits 3-0-0: 3

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	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
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: Introduction, Definitions and Properties, Static CMOS Inverter, Static and Dynamic Power Dissipation, CMOS inverter delay time definitions and calculations, FinFET.

DESIGNING COMBINATIONAL & SEQUENTIAL LOGIC GATES in CMOS: Static CMOS Design, Dynamic CMOS Design, Power Consumption in CMOS Gates 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.

Advanced Digital IC Design: Block level design

Learning Resources:

Text Books:

1. Jan M Rabaey, Digital Integrated Circuits, 2nd Edition, Pearson Education, 2003.

Reference Books:

1. Sung-Mo Kang, CMOS Digital Integrated Circuits, 3rd Edition, McGraw-Hill, 2003

Other Suggested Readings:

1. NPTEL Courses

Course Code: EC255	Probability Theory and Stochastic Processes	Credits 3-0-2: 4

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	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	2	–	–	–	–	–	–	–	–	–	2	–	–
CO-3	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	2	–	–	–	–	–	–	–	–	–	–	–	–

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, 4th Edition, 2017.
2. A.Papoulis, Probability, Random variables and Stochastic Processes, McGraw Hill, 4th Edition, 2017.
3. Scott Miller, Donald Childersm, Probability and Random Processes, 2nd Edition, Elsevier, 2012.

Reference Books:

1. Athanasios Papoulis and S., Unnikrishna Pillai. Probability, Random Variables and Stochastic Processes, 4th Edition.,2002, TMH.
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, 3rd Edition, PE.
4. S.P. Eugene Xavier, Statistical Theory of Communication, 1997, New Age Publications, 1997.

Other Suggested Readings:

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

Course Code: EV256	CMOS Analog IC Design Lab	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the significance of different biasing styles and apply for analog circuits
CO-2	Design basic building blocks for analog CMOS circuits
CO-3	Comprehend the stability issues of the systems and design OP-amp fully compensated against process, supply and temperature variations
CO-4	Identify suitable topologies of the constituent sub systems and corresponding circuits as per the specifications of the system.
CO-5	Design Analog integrated circuits with parasitic effects.

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	1	-	-	-	2	1	-	-	-	-
CO-2	3	2	3	1	3	-	-	-	2	1	-	-	-	-
CO-3	3	3	3	3	3	-	-	-	2	1	-	-	2	-
CO-4	3	3	3	3	3	-	-	-	2	1	-	-	2	-
CO-5	3	3	3	3	3	-	-	-	2	1	-	-	2	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

All circuits till post layout

Lambda calculation for PMOS & NMOS, Transconductance plots, Single transistor amplifier with different loads,
Current sinks: Basic current sink.
Current sources: Basic current source.
Current mirrors: Basic current mirror, Wilson current mirror
CMOS differential amplifier with current mirror load.
Two stage Operational amplifier.

Learning Resources:

Text Books:

1. Behzad Razavi, Design of Analog CMOS Integrated Circuit, McGraw Hill Education, 2nd Edition 2017
2. Pr Gray and Rg Meyer, Analysis and Design of Analog Integrated Circuits, 5th Edition, Wiley, 2009.
3. Mohammed Ismail and Terri Fiez, Analog VLSI: Signal and Information Processing, McGrawHill, 1994.

Reference Books:

1. Geiger, Allen and Stradder, VLSI Design Techniques for Analog and Digital Circuits, Tata McGraw-Hill Education, 2010.

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: EV257	CMOS Digital IC Design Lab	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

CO-1	Design of combinational and sequential circuits using Verilog HDL/ VHDL
CO-2	Synthesize digital circuit targeting state of the art FPGA
CO-3	Design combinational and sequential circuits at circuit level using EDA tools
CO-4	Implement efficient techniques at circuit level for improving power and speed

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	3	-	-	-	2	2	-	-	1	-
CO-2	3	3	3	2	3	-	-	-	2	2	-	-	1	-
CO-3	3	3	3	1	3	-	-	-	2	2	-	-	1	-
CO-4	3	3	3	3	3	-	-	-	2	2	-	-	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Cycle 1

Design and Simulation of CMOS Inverter to study the transfer Characteristics by varying the design constraints using EDA Tools
Design and Simulation of logic gates using various logic styles and compare the performance
Design a Full Adder cell using various configurations proposed in the literature and simulate to compare the performance using EDA tools

Cycle 2:

Design, Develop HDL model, Simulate and Synthesize
32-bit Parallel adder using 8-bit adder module, 32-bit Shift register using 8-bit Shift register module
RTL to GDS-II: Design any System as a case Study
EDA Tools: Mentor Graphics Tools

Learning Resources:

Text Books:

1. Samir Palnitkar, Verilog HDL, 2nd Edition, Pearson Education, 2003.

Reference Books:

1. Douglas Perry, VHDL: Programming by Example, 2017

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: BT281	Design Principles of Living Systems	Credits 2-0-0: 2

Prerequisites: None

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

CO1	Realize the significance of biomolecules for sustaining life
CO2	Identify the difference between unicellular to multi-cellular organisms
CO3	Understand the central dogma of life
CO4	Apply the concepts of biology for engineering the cell

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1							1					1	1	2
CO2							1	1	1	1		1	1	2
CO3							1					1	1	2
CO4						1	1	1	1		1	1	1	2

Syllabus:

Biomolecular design - structure and functions: chemical basis of life, water, carbon, proteins, nucleic acids, carbohydrates, lipids and membranes and first cells. design principles of cell and organelles.

Information processing in living system: intra and inter cellular communication: central dogma, genetic code, gene and control of gene expression, cell cycle, cell–cell Interactions, biological signal transduction, concept of networks in the cell, interaction between cell and environment, quorum sensing and biofilm formation.

Biomolecular machines and motors: linear and rotary molecular motors: cytoskeletal motor proteins.

Bioengineering: biological data types; Biocomputing; DNA based data storage, synthetic biology, synthetic gene regulatory circuit and application; biomolecules for sensor design, biomedical instrumentation in disease diagnosis, bioimaging techniques and analysis in clinical diagnosis.

Learning Resources:

Text Books:

1. Biological Science, Quillin, Allison Scott Freeman, Kim Quillin and Lizabeth Allison, Pearson Education, 2016, 5th Edition.
2. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox Macmillan Higher Education, 2017, 7th edition,

Reference Books:

1. Biotechnology for Beginners, ReinhardRenneberg, Viola Berkling and VanyaLoroch, Academic Press, 2017, 1st Edition.

2. Molecular Diagnostics**,** Harald Seitz, Sarah Schumacher, Springer, 2013, 1st Edition

Online Resources:

1. DNA storage: research landscape and future prospects, National Science Review, Oxford academic, 2020 (https://academic.oup.com/nsr/article/7/6/1092/5711038)
2. DNA data storage: https://wyss.harvard.edu/technology/dna-data-storage.
3. Synthetic Biology: Integrated Gene Circuits, Science, 2011 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4117316)
4. Synthetic biology: applications come of age, Nature Reviews Genetics, 2010 (https://www.nature.com/articles/nrg2775)

5th Semester

Course Code: EC301	Digital Signal Processing	Credits 3-0-0:3

Pre-Requisites: None

Course Outcomes:

CO-1	Able to identify, formulate, and solve engineering problems in the area of signal processing.
CO-2	Able to implement FFT algorithms for computing the DFT
CO-3	Able to design and implementation of FIR and IIR filters.
CO-4	Able to 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	–	–	–	–	–	–	–	–	3	2
CO-2	3	3	2	2	–	–	–	–	–	–	–	–	2	2
CO-3	3	3	3	3	–	–	–	–	–	–	–	2	2	2
CO-4	3	3	3	3	–	–	–	–	–	–	–	2	2	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Review of signals and Systems:

DISCRETEFOURIERTRANSFORM(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, Quantization effects in the computation of DFT - Direct & FFT method.

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. Quantization of filter coefficients - Sensitivity to Quantization of filter coefficients, Quantization of coefficients in FIR filters, Roundoff effects in digital filters - Limit cycle, scaling to prevent overflow.

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, cascade equivalence, Filter design Implementation for sampling rate conversion, Applications: Phase-Shifters, Digital Filter-Banks, Sub band Coding of Speech Signals, Quadrature Mirror Filters, Trans multiplexers, Over Sampling A/D and D/A Conversion.

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.B.Venkataramani, M.Bhaskar, "Digital Signal Processors, Architecture, Programming and Application", Tata McGraw Hill, New Delhi,2003
2. A.V. Oppenheim and Ronald W. Schafer, Discrete Time Signal Processing, 2ndEdition, PHI,2000.
3. S.K.MITRA, Digital Signal Processing – A computer Based Approach, 4thEdition,MGH, 2010.

Reference Books:

1. Multi Rate Systems and Filter Banks – P.P.Vaidyanathan – PearsonEducation.
2. Fundamentals of Digital Signal Processing using Matlab – Robert J. Schilling, Sandra L. Harris, Thomson,2ndEdition,2010

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: EV302	Pulse and Switching Circuits	Credits 3-0-0:3

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the response of linear and non-linear wave shaping circuits
CO-2	Design sweep circuits
CO-3	Design and analyze multi vibrators
CO-4	Apply synchronization techniques to sweep circuits

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	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-6	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Unit1: Linear Wave Shaping:
High Pass and Low Pass RC Circuits and their Response for Sinusoidal, Step Voltage, Pulse, Square Wave and Ramp Inputs. High Pass RC Circuit as a Differentiator. Low Pass RC Circuit as an Integrator. Attenuators and their Application as CRO Probe. RL and RLC Circuits and their response for step input. Ringing circuit.

Unit II: Non-Linear Wave Shaping:
Diode clippers. Transistor Clippers. Clipping at two independent levels. Comparator – Applications of voltage Comparators – Diode Comparator. Clamping Operation. Clamping Circuits using Diode with Different Inputs. Clamping Circuit Theorem. Practical Clamping circuits. Effect of diode Characteristics on Clamping Voltage.

Unit III: Switching Characteristics of Devices:
Diode as a switch, piecewise linear diode characteristics, Transistor as a switch, Break down voltage consideration of transistor, saturation parameters of Transistor and their variation with temperature, Design of transistor switch, transistor-switching times.

Unit IV: Multivibrators:
Analysis and Design of Bistable, Monostable, Astable Multivibrators and Schmitt trigger using transistors.

Unit V: Time Base Generators:
General features of a time base signal, methods of generating time base waveform, Miller and Bootstrap time base generators - basic principles, Transistor miller time base generator, Transistor Bootstrap time base generator, Current time base generators.

Unit VI: Synchronization and Frequency Division:
Principles of Synchronization – Synchronization of Astable Multivibrators. Synchronization of Sweep Circuits with Symmetrical Signals.

Learning Resources:

Text Books:

1. Integrated Electronics, J. Millman, C. Halkias, and Chetan D. Parikh, 2nd Edition, Tata McGraw-Hill , 2017
2. Pulse, Digital and Switching Waveforms, J. Millman, H. Taub and SuryaPrakash Rao M., 3rd Edition, McGraw-Hill, 2017
3. Linear Integrated Circuits, D. Roy Choudhary, Shail B. Jain, 5th Edition, New Age International, 2018

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: EV303	Mixed Signal Circuits	Credits 3-0-0:3

Pre-Requisites: None

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Review: Basic building blocks**,** Process and 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.

Performance of Sample-and-Hold Circuits: Testing Sample and Holds, MOS Sample-and-Hold Basics, Examples of CMOS S/H Circuits, Input-Offset Voltage Errors, Charge-Injection Errors, Making Charge-Injection Signal Independent, Minimizing Errors Due to Charge-Injection.

Comparators: Characterization of comparator, Design of Linear response comparators, slew-rate limited comparators, Latched Comparators, Latch-Mode Time Constant, Architecture of High-speed 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.

Learning Resources:

Text Books:

1. David A Johns, Ken Martin: Analog IC design, Wiley 2008.
2. Behzard Razavi, “Design of Analog CMOS Integrated Circuits” McGraw Hill Education, 2017, 2nd Edition .
3. R. Jacob Baker “CMOS: Mixed-Signal Circuit Design” IEEE Press Series on Microelectronic Systems, 2008, 2nd Edition

Reference Books:

1. R Gregorian and G 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, Pui-In Mak, “Analog and Mixed-Signal Circuits in Nanoscale CMOS”, Springer publications, 2024.

Other Suggested Readings:

1. https://youtube.com/playlist?list=PLLDC70psjvq5vtrb0EdII4xIKA15ec-Ij&feature=shared

Course Code: EC304	Advanced Microcontrollers	Credits 3-0-0:3

Pre-Requisites: None

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	-	-	2	-	-	-	-	-	2	1	1	1
CO-2	-	3	-	-	2	-	-	-	1	-	2	1	1	1
CO-3	-	3	-	-	-	-	-	-	1	-	2	1	2	2
CO-4	-	2	-	-	3	-	-	-	1	-	2	1	1	1
CO-5	-	2	-		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 80X86microprocessor, Architecture of 8086, Memory organization, 8086 system connections and timing. Overview of 8051 microcontroller, Architecture, Instruction set and addressing modes.

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, Debug and Trace features.

ARM Cortex-M4 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

ARM cortex-M4 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.

TivaC Series ARM Cortex-M4 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; Third Edition, 2013.
2. Ata Elahi-Trever Arjeski, ―ARM Assembly language with hardware experiment‖, Springer Int. Publishing, 2015.
3. Steve Furber , ―ARM system on chip Architecture‖, Pearson Publications, Second Edition,2000.
4. D. V. Hall. Microprocessors and Interfacing, TMGH.Third Edition 2017.
5. Wrox, ― Professional Embedded ARM Development‖

Reference Books:

1. William hohl and Christoper Hinds, ―ARM assembly language fundamentals and Techniques‖CRC, Second Edition, 2015.
2. M.A. Mazidi, J.G. Mazidi, R.D. Mckinlay, ―The 8051 Microcontroller and Embedded Systems‖, Pearson Second Edition, 2007.

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: EV305	Mixed Signal Circuits Lab	Credits 0-1-2:2

Pre-Requisites: None

Course Outcomes:

CO-1	Implement discrete time signal processing circuits
CO-2	Implement layout techniques specific to mixed signal IC design
CO-3	Design OP-amp for mixed signal environment
CO-4	Design a high-speed comparator with high resolving capability
CO-5	Design data converters and RF circuits for mixed signal 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	3	1	1	2	-	-	-	-	-	-	-	-
CO-2		1	3	1		3	-	-	-	-	-	-	-	-
CO-3			2	1	1	1	-	-	-	-	-	-	-	-
CO-4		1	2	1		1	-	-	-	-	-	-	-	-
CO-5	1	1	3			2	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Cycle 1:

1) Fully compensated op-amp with resistor and miller compensation
2) comparator design a. linear Response b. Slew-rate limited

Cycle 2:

3) Switched capacitor circuits
   i. Parasitic sensitive integrator
   ii. Parasitic insensitive integrator

4) Data converters (ADC, DAC for given specifications)
5) Layouts of All the circuits Designed and Simulated

Learning Resources:

Text Books:

1. David A johns, Ken Martin, Analog Integrated Circuit Design, Wiley, 2008.
2. R. Gregorian and G.C Ternes, Analog MOS Integrated Circuits for Signal Processsing, Wiley, 1986.

Reference Books:

1. Roubik Gregorian, Introduction to CMOS OpAmp and Comparators, Wiley, 1999.
2. Alan Hastlings, The art of Analog Layout, Wiley, 2005.

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: EC306	Microcontrollers Lab	Credits 0-1-2:2

Pre-Requisites: None

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	-	-	2	-	-	-	2	2	2	1	1	1
CO-2	-	3	-	-	2	-	-	-	2	2	2	1	1	1
CO-3	-	3	-	-	-	-	-	-	2	2	2	1	2	2
CO-4	-	2	-	-	3	-	-	-	2	2	2	1	1	1
CO-5	-	2	-		3	-	-	-	2	2	-	-	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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, Second Edition, 2000.
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

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: SM344	Industrial Systems and Management	Credits 3-0-0:3

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the basic principles, approaches and functions of management and apply Concepts to specific situations.
CO-2	Understand marketing management process and apply marketing mix in the formulation of marketing strategies during the life cycle of product.
CO-3	Identify and utilize various techniques for improving productivity using work study.
CO-4	Apply the concepts and tools of quality engineering in the design of products and process controls

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	1	1	1	1	3	1	1	1	1	3
CO-2	1	1	2	2	3	1	1	1	1	1	1	1	1	3
CO-3	1	1	1	1	1	1	2	1	3	2	1	1	1	3
CO-4	1	1	1	1	3	1	1	1	2	1	3	1	1	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Part–1: Introduction - Overview of organizational theory and theoretical perspectives

Part-2: Rational and natural systems

The evolution of organizational theory - rational systems and Natural systems

- Work study: Productivity and its role in the economy; Techniques for improving productivity;
- Method study.
- Quality management: Dimensions of quality; Process control charts; Acceptance sampling;
- Taguchi‘s Quality Philosophy; Quality function deployment; Introduction to TQM. Process
- control charts both attributes and variables. Sampling Plan, LTPD and AOQL concepts.
- Quality management: Dimensions of quality; Process control charts; Acceptance sampling;
- Taguchi‘s Quality Philosophy; Quality function deployment; Introduction to TQM. Process
- control charts both attributes and variables. Sampling Plan, LTPD and AOQL concepts.

Part - 3: Organizational behavior

- The individual, The Group, Organization system (structure and culture)

Part-4: Open systems and behavioral decision-making

Part - 5: Other management topics

- Marketing management process; 4P‘s of marketing mix; Target marketing; Product life cycle and marketing strategies
- Project Management: Project activities; Network diagrams; Critical path method (CPM);
- Programme Evaluation and Review Technique (PERT). Project crashing. Slack computations, Resource leveling

Reading:

- Robbins, S. P., & Judge, T. A. Organizational behavior, 16th Edition 2016.
- Jones, G. R., & Jones, G. R. (2013). *Organizational theory, design, and change*. Upper Saddle River, NJ: Pearson, 7th Edition 2013.

- Taylor, F.W. 1916. Principles of Scientific Management, 30-144
- Roethlisberger, F.J. & Dickson, W.J. 1939. Management and the Worker. Cambridge, MA: Harvard University Press. Chapters 1, 17, 21-25, 3-18, 379-408, 493-589
- Mahajan,M. (2000). *Industrial engineering and production management*. Dhanpath Rai & Co.
- Besterfield (2015). Total Quality Management. Pearson Education India; 4 editions
- Khanna,O. P. (2018-2019). *Industrial engineering and management*. Dhanpat Rai.
- Meridith, J. R. (2011). Project Management. A Management Approach, 8th Edition.
- Stinchcombe, A. 1965. ―Social Structure and Organizations‖ in James G. March (ed.) Handbook of Organizations. Chicago, IL: Rand McNally. 142-193.
- Cyert, R.M., & March, J.G. 1963. Chapter 7: A summary of basic concepts. From: A behavioral theory of the firm. 161-176
- Kottler, P., & Keller, K. L. (2015). Marketing Management 15e Global Edition.

Additional Readings

- Weber, M. Economy and Society 1978 pp.212-254, 956-975
- Roy, D.F. 1960. ―Banana Time‖: Job Satisfaction and Informal Interaction. Human Organization. 18.
- Selznick, P. 1948. ―Foundations of the Theory of Organization‖ American Sociological Review, 13: 25-35.
- Olsen, J.P. 2001. Garbage cans, new institutionalism, and the study of politics. *Amer. Pol. Science Review*, 95: 191-198.

Course Code: IC3XX	Mandatory Non-credit Course*	Credits 10-0:0

Pre-Requisites: None

Course Outcomes:

CO-1	
CO-2	
CO-3	
CO-4	
CO-5	

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	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Syllabus:

Learning Resources:

Text Books:

Reference Books:

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

6th Semester

Course Code: EV351	Analog and Digital communications	Credits 4-0-2:4

Pre-Requisites: None

Course Outcomes:

CO-1	Introduce the principles of continuous wave modulation
CO-2	Evaluate the performance of modulation and demodulation techniques
CO-3	Construct the mathematical model for optimum receiver
CO-4	Study source coding and channel coding 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	1	1	-	-	2	-	1	-	-	-	-	-	-	-
CO-2	2	3	-	-	1	2	1	-	-	-	-	-	-	-
CO-3	2	1	-	-	1	-	1	-	-	-	-	-	-	-
CO-4	2	3	-	-	-	1	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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

Analog Communication:
Necessity of Modulation: Amplitude Modulation (AM), Envelop Detection, Limitations of AM, DSB-SC, SSB, Frequency Division Multiplexing, Angle Modulation, Frequency Modulation, Narrowband FM, Generation of FM, Detection of FM, Noise in AM and FM, Pre-emphasis and Deemphasis.

Pulse Modulation —Pulse Amplitude Modulation, Pulse width Modulation, Pulse Position Modulation, Pulse code modulation, TDM, delta modulation., Line coding formats, Nyquist criterion for Zero ISI, Raised cosine filter.

Digital Communication:
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: Coherent binary modulation techniques (BPSK, BFSK), Coherent quadrature modulation techniques (QPSK), Non-Coherent binary modulation techniques (DPSK), QAM, M-ary modulation techniques, bandwidth efficiency.

Error control Coding: Linear block Codes, syndrome decoding, Introduction to Cyclic and convolutional codes.

Learning Resources:

Text Books:

1. Simon Haykin , Communication Systems , Wiley India Pvt. Ltd., 2009, 5th Edition.

Reference Books:

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

Other Suggested Readings:

1. https://nptel.ac.in/courses/117/105/117105143/

2. https://nptel.ac.in/noc/courses/noc17/SEM2/noc17-ec11/
3. https://onlinecourses.nptel.ac.in/noc21_ee74/preview

Course Code: EV352	VLSI Verification and Testing	Credits 3-0-0:3

Pre-Requisites: CMOS Digital IC Design

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, 2nd edition, 2003.
3. G. De Micheli. Synthesis and optimization of digital circuits, 1st edition, 1994.

Reference Books:

1. M. Huth and M. Ryan, Logic in Computer Science modeling and reasoning about systems, Cambridge University Press, 2nd Edition, 2004.
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, 1st edition, 1992.

Other Suggested Readings:

1. NPTEL Courses (https://nptel.ac.in/courses/106103016).
2. MIT Open Course Ware, etc.

Course Code: EV353	VLSI Verification and Testing Lab	Credits 0-1-2:2

Pre-Requisites: None

Course Outcomes:

CO-1	Develop packet , class, driver , mail box and score board for DUT
CO-2	Analyze line, code and functional coverage
CO-3	Examine the assertions for DUT
CO-4	Construct binary decision diagram and apply temporal logic
CO-5	Apply built in self-test in modern digital 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	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:

1. Introduction to test bench architecture.
2. Development of an exhaustive test bench for the 1-bit full adder.
3. Development of exhaustive test bench for 16X1 Multiplexer using file reading writing features.
4. Development of layered testbench components for functional verification of an 8-bit full adder.
5. Development of layered testbench components for functional verification of 8-bit ALU.
6. Development of layered testbench components for functional verification of synchronous FIFO.
7. Development of layered testbench components for functional verification of Round Robin Arbiter.
8. Design for Test and Automatic Test pattern Generation for a 4-bit counter.
9. Design for Test and Automatic Test pattern Generation for a 4-bit counter.
10. Perform the logic equivalence (formal verification).

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, 2nd edition, 2003.
3. G. De Micheli. Synthesis and optimization of digital circuits, 1st edition, 1994.

Reference Books:

1. M. Huth and M. Ryan, Logic in Computer Science modeling and reasoning about systems, Cambridge University Press, 2nd Edition, 2004.
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, 1st edition, 1992.

Other Suggested Readings:

1. NPTEL Courses (https://nptel.ac.in/courses/106103016).
2. MIT Open Course Ware, etc.

Course Code: EC354	Embedded and Real time Operating Systems	Credits 3-0-0:3

Pre-Requisites: None

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 Embedded systems.
CO-5	Identify Fundamental Issues, Computation models in Hardware-software co-design, and Hardware Software Trade-offs.

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-MicroC/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. Introduction to Embedded Systems -Shibu K.V, McGrawHill

2. Embedded Systems Design –Santanu Chattopadhyay, PHI, 2nd Edition, 2013
3. Embedded System Design -Frank Vahid, Tony Givargis, JohnWiley.

Reference Books:

1. Embedded/Real-Time Systems: Concepts Design and Programming, K.V.K.K. Prasad Dreamtech,2005.
2. An Embedded Software Primer -David E. Simon, Pearson Education.

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: EC356	Innovation and Start-up activity*	Credits 0-1-2:2

Pre-Requisites: None
Course Outcomes: At the end of the course, the student will be able to:

CO1	Think creatively and transform ideas into reality.
CO2	Differentiate market transforming strategy
CO3	Create a complete business plan and workout the budget plan
CO4	Understand the startup financing cycle

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	1	2	2	2	2	1	2	1	2	1	1	2
CO2			1	1	1	1	1	1	1		1	1		
CO3	1		1	1	2	1	2	1	1	1	2	1	1	1
CO4				1	1	1	1	1			3	1		

Detailed Syllabus:

Creativity & Discovery
Definition of Creativity, self test creativity, discovery and delivery skills, The imagination threshold, Building creativity ladder, Collection of wild ideas, Bench marking the ideas, Innovative to borrow or adopt, choosing the best of many ideas, management of tradeoff between discovery and delivery, Sharpening observation skills, reinventing self, Inspire and aspire through success stories

From Idea to Startup
Introduction to think ahead backward, Validation of ideas using cost and strategy, visualizing the business through value profile, activity mapping, Risks as opportunities, building your own road map

Innovation career lessons
Growing & Sharing Knowledge, The Role of Failure In Achieving Success, Creating vision, Strategy, Action & Resistance: Differentiated Market Transforming Strategy; Dare to Take Action; Fighting Resistance; All About the startup Ecosystem; Building a Team; Keeping it Simple and Working Hard.

Action driven business plan
Creating a completed non-business plan (a series of actions each of which moves your idea toward implementation), including a list of the activities to be undertaken, with degrees of importance (scale of 1 to 3, where 1 is _most important‘). A revision of the original product or service idea, in light of information gathered in the process, beginning to design the business or organization that will successfully implement your creative idea. Preparing an activity map.

Startup financing cycle
Preparing an initial cash flow statement, showing money flowing out (operations; capital) and flowing in. Estimate your capital needs realistically. Prepare a bootstrapping option (self financing). Prepare a risk map. Prepare a business plan comprising five sections: The Need; The

Product; Unique Features; The Market; Future Developments. Include a Gantt chart (project plan – detailed activities and starting and ending dates); and a project budget.

Innovation Activities:

- Introduction and briefing
- Ice-breaker activities
- Review sessions on Design thinking
- Ideate and create real world products
- Build and sell the product exercise
- Find your customer for a product
- Design a product for a customer
- Build a prototype of the product, Revise and re-build with the customer feedback
- Field visits for scouting for problems
- Exposure to gross root innovations and interactive sessions with the innovators

Start-up activities

- Understanding Business canvas
- Develop a business model for the product
- Process of startup registration
- Interaction with founders/CEOs of startups
- Exploring the sources of seed funding
- Exploring other sources of funding: Venture capitalists, Angel Investors
- Conducting Boot camps, hackathons.

Other activities:

- Classroom hacks
- Process skills
- Experience driven approach
- Maximizing the talent

Suggested Readings:

1. Vasant Desai, *"Dynamics of Entrepreneurial Development and Management"*, Himalaya Publishing House, 1997.
2. Prasanna Chandra, *"Project – Planning , Analysis, Selection, Implementation and Review",* Tata McGraw-Hill Publishing Company Ltd., 1995.
3. B. Badhai, ―*Entrepreneurship for Engineers*‖, Dhanpath Rai & Co., Delhi, 2001.
4. Stephen R. Covey and A. Roger Merrill, ―*First Things First",* Simon and Schuster, 2002.
5. Robert D. Hisrich and Michael P.Peters, *" Entrepreneurship*‖, Tata McGRaw Hill Edition, 2002.

7th Semester

Course Code: EV401	Semiconductor Materials Synthesis and characterization	Credits 3-0-0:3

Pre-Requisites: None

Course Outcomes:

CO-1	Describe the principles of optical and electron microscopy
CO-2	Select an imaging mode of SEM/TEM for a specific analysis
CO-3	Interpret electron and X-ray diffraction data
CO-4	Select a Thermal analysis technique for material analysis

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	3	2	2	2	1	2	1	1	2	2
CO-2	2	2	-	1	3	1	-	-	1	1	1	1	1	-
CO-3	3	2	-	2	3	1	-	-	1	1	-	1	1	-
CO-4	3	2	-	2	3	1	-	-	1	1	-	1	1	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Processing techniques: bulk crystal growth, thin films, Combustion Synthesis, Spray Pyrolysis, Electrospinning, Hydrothermal

Fundamentals of Crystallography: Lattice Geometry, The Weiss Zone Law, Symmetry Elements, Translational Symmetry, Rotational Symmetry, Reflection Symmetry, Restrictions on Symmetry Elements, Possible Combinations of Rotational Symmetries, Crystal Systems, Space Lattices (Bravais Lattices).

X-ray Diffraction: Reciprocal Lattice, Stereographic projection, Basics of X-rays, X-ray diffraction and methods, X-ray techniques: X-ray diffraction- Generation and characteristics of x-ray, Lattice planes and Bragg's law, Theory of diffraction, determination of particle size and micro/macro strains, reciprocal lattice, electron diffraction, energy loss spectroscopy, SAXS, XRF, in-situ methods in XRD.

Optical Microscopy: (working principle and data interpretation), Introduction to Electron microscopy (SEM, TEM, EDX, WDS, EPMA) – Working principle and electron matter interaction.

Characterization: Working principle and analysis for Mechanical Characterization (Hardness, tensile test), Thermal analysis (e.g., DTA, DSC, TGA, DMA).

Synthesis of Nanomaterials: CVD, Nucleation and Growth, ALD, Epitaxy, MBE. Compound semiconductor hetero-structure growth and characterization: Quantum wells and Thickness measurement techniques: Contact - step height, Optical - reflectance and ellipsometry. AFM. Characterization techniques for nanomaterials: FTIR, XRD, AFM, SEM, TEM, EDAX etc. Applications and interpretation of results. Emerging nano materials: Nanotubes, nanorods and other nano structures, LB technique, soft lithography etc. Microwave-assisted synthesis, Self-assembly etc.

Learning Resources:

Text Books:

1. Annelise Kopp Alves, Carlos P. Bergmann, Felipe Amorim Berutti, “Novel Synthesis and Characterization of Nanostructured Materials”, Springer Berlin, 2013.
2. Anthony Kelly and Kevin M. Knowles, Crystallography and Crystal Defects.
3. B. D. Cullity and S. R. stock, Elements of X-ray Diffraction;
4. Goldstein et al, Solar-Grade Scanning electron microscopy and x-ray microanalysis.
5. D.B. Williams and C.B. Carter, Transmission Electron Microscopy - A Textbook for Materials Science.

Reference Books:

1. Douglas B. Murphy, Fundamentals of light microscopy and electronic imaging’, Wiley-Liss, Inc. USA, 2001.
2. Editors C. Richard Brundle, Charles A. Evans, Jr., Shaun Wilson, Butterworth-Heinemann,Encyclopedia of Materials Characterization, Surfaces, Interfaces, Thin Films,’ Boston, US.
3. B.D. Cullity and S.R. Stock,Elements of X-ray diffraction’ Prentice Hall, Inc. USA, 2001,
4. Transmission electron microscopy” D.B. Williams and C. Barry Carter, 4 volumes, Springer, The USA,1996.

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: EV402	Semiconductor Device Characterization Lab	Credits 0-1-2:2

Pre-Requisites: CMOS Digital IC Design

Course Outcomes:

CO-1	Understand the material and electrical parameters of intrinsic and extrinsic semiconductor materials.
CO-2	Understand the basic characteristics of MOS transistor.
CO-3	Apply MOS understanding to use advance design TCAD tool to describe the basic characteristics of BJT and MOS transistors.
CO-4	To use advance design TCAD tool to analyze the characteristics of the inverter.

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	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	–	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

1. Overview of Sentarus TCAD software
2. GUI of 2-D PN junction Diode, BJT
3. GUI of 2-D NMOS and PMOS
4. PN DIODE characterization using Sdevice
5. NMOS and PMOS Characterization using Sdevice
6. CMOS Characterization
7. NMOS and PMOS with multigate

Learning Resources:

Text Books:

1. Crystallography and Crystal Defects; Anthony Kelly and Kevin M. Knowles.
2. Elements of X-ray Diffraction; B. D. Cullity and S. R. stock
3. Solar-Grade Scanning electron microscopy and x-ray microanalysis; Goldstein et al.
4. Transmission Electron Microscopy - A Textbook for Materials Science; D.B. Williams and C.B. Carter.

Reference Books:

1. Fundamentals of light microscopy and electronic imaging' Douglas B. Murphy, 2001, Wiley-Liss, Inc. USA.

2. Encyclopedia of Materials Characterization, Surfaces, Interfaces, Thin Films,' Editors C. Richard Brundle, Charles A. Evans, Jr., Shaun Wilson, Butterworth-Heinemann, Boston, US.
3. Elements of X-ray diffraction' B.D. Cullity and S.R. Stock, 2001, Prentice Hall, Inc. USA
4. Transmission electron microscopy" D.B. Williams and C. Barry Carter, 4 volumes, Springer, 1996. The USA.

Other Suggested Readings:

1. NPTEL Courses

Course Code: EV403	Data Communication Networks	Credits 2-0-0:2

Pre-Requisites: Probability Theory and Stochastic Processes

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, 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.

Data Link layer

Framing; error control, error detection, Internet Checksum 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, IEEE802.3; ETHERNET, Fast ETHERNET, Gigabit ETHERNET; IEEE 802.11 WiFi MAC protocol.

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; DHCP, NAT; IPv6summary.

Transport Layer:

UDP, segment structure and operation; TCP, segment structure and operation.

Network Security:

Security Requirements and Attacks, Confidentiality with Conventional Encryption, Message Authentication and Hash Functions, Public-Key Encryption and Digital Signatures, Secure Socket Layer, IP Security.

Selected Application layer Protocols:

Web and HTTP.

Learning Resources:

Text Books:

1. D. Bertsekas and R. Gallagar, Data Networks, PHI,1992, 2/e.
2. J.F. Kurose and K. W. Ross: Computer Networking, A Top-Down Approach, Pearson/Addison Wesley,2016, 7/e.
3. BEHROUZ A. FOROUZAN, Data Communications and Networking, Tata McGraw-Hill, New Delhi,2006, 4th Edition.

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Reference Books:

1. DOUGLAS E COMER, Computer Networks and Internet, Pearson Education Asia,2000.
2. Leon-Garcia and I. Widjaja: Communication Networks; McGraw Hill,2017, 2/e.
3. S. Tanenbaum, Computer Networks, PHI,2013, 5/e.
4. W. Stallings, Data and Computer Communication, Prentice-Hall,2017, 10/e.

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: EV404	Low Power IC Design Lab	Credits 0-1-2:2

Pre-Requisites: None

Course Outcomes:

CO-1	Low power design techniques at different levels of a System design flow
CO-2	Design a 32-bit pipelined MIPS processor with a specific instruction set depending the application employing low power techniques at architectural level
CO-3	Implement the 32-bit pipelined MIPS processor using standard cell based semicustom design methodology.
CO-4	Analyse the performance of a system and employ various techniques to meet the required power and tine budget.

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	1	-	-	-	-	-	-	-	-
CO-2	2	1	-	2	1	1	-	-	-	-	-	-	-	-
CO-3	2	-	2	1	1	-	-	-	-	-	-	-	-	-
CO-4	2	-	-	2	3	2	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Implement a high speed and low power 32-bit adder using 8-bit adder module.
Implement a 32-bit MIPS processor by employing low power techniques in the design of Datapath and control units
Perform the functional simulation, Static Timing Analysis and post synthesis timing verification and RTL to GDS-II
EDA Tools: Synopsis Tools

Learning Resources:

Text Books:

1. Kiat Seng Yeo and Kaushik Roy, Low- Voltage, Low-Power VLSI Subsystems, Edition 2009, TataMc Graw Hill
2. Soudris D, Piguet C and Goutis C, Designing CMOS Circuits for Low Power, Kluwer AcademicPublishers, 2002

Reference Books:

1. Jan Rabaey, Low Power Design Essentials, Springer.
2. Samir Palnitkar, Verilog HDL, 2nd Edition, Pearson Education, 2003.

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: EV430	Design Project	Credits 0-0-2:1

Pre-Requisites: None

Course Outcomes:

CO-1	
CO-2	
CO-3	
CO-4	
CO-5	

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	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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Learning Resources:

Text Books:

1. Authors, Title of the Text Book, Name of the Publisher, Year of publication, Edition
2. Authors, Title of the Text Book, Name of the Publisher, Year of publication, Edition

Reference Books:

1. Authors, Title of the Text Book, Name of the Publisher, Year of publication, Edition
2. Authors, Title of the Text Book, Name of the Publisher, Year of publication, Edition

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: EV449	Summer Internship/ EPICS	Credits 0-0-2:1

Pre-Requisites: None

Course Outcomes:

CO-1	
CO-2	
CO-3	
CO-4	
CO-5	

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	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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Learning Resources:

Text Books:

1. Authors, Title of the Text Book, Name of the Publisher, Year of publication, Edition
2. Authors, Title of the Text Book, Name of the Publisher, Year of publication, Edition

Reference Books:

1. Authors, Title of the Text Book, Name of the Publisher, Year of publication, Edition
2. Authors, Title of the Text Book, Name of the Publisher, Year of publication, Edition

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

8th Semester

Course Code: EV499	Project work	Credits 0-0-8:4

Pre-Requisites: None

Course Outcomes:

CO-1	
CO-2	
CO-3	
CO-4	
CO-5	

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	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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Learning Resources:

Text Books:

1. Authors, Title of the Text Book, Name of the Publisher, Year of publication, Edition
2. Authors, Title of the Text Book, Name of the Publisher, Year of publication, Edition

Reference Books:

1. Authors, Title of the Text Book, Name of the Publisher, Year of publication, Edition
2. Authors, Title of the Text Book, Name of the Publisher, Year of publication, Edition

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Dept. Elective-I

Course Code EC315	Low Power VLSI Design	Credits 3-0-0:3

Prerequisites: EV252, EV254 -CMOS Analog IC Design ,CMOS Digital IC Design

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

CO1	Identify clearly the sources of power consumption in a given VLSI Circuit.
CO2	Design low power arithmetic circuits and systems.
CO3	Choose the types of SRAMs/ DRAMs for the given Low power applications.
CO4	Decide at which level of abstraction is advantageous to implement low power techniques in a VLSI system design.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	-	1	1	-	-	-	-	-	--	-	2	2
CO2	-	-	-	3	-	-	-	-	-	-	-	-	2	2
CO3	-	2	-	2	3	-	-	-	-	-	-	1	2	2
CO4	-	-	-	1	-	-	-	-	-	-	-	-	2	2

Detailed 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

Reading:

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

Course Code: EC316	Computer Architectures	Credits 3-0-0:3

Pre-requisites:None.

Course Outcomes:After the completion of the course the student will be able to:

CO1	Understand the basic structure and operations of digital computer
CO2	Design arithmetic and logic unit
CO3	Evaluate performance of memory systems
CO4	Design and analyze pipelined control units
CO5	Understand parallel processing architectures.
CO6	Familiarize various ways of Communicating with I/O devises and standard interfaces

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	1	1	2	2	2	1	-	-	-	2	-
CO2	3	1	1	1	1	1	2	1	1	-	-	-	2	2
CO3	3	2	3	2	3	2	2	2	1	-	-	-	2	2
CO4	3	2	3	1	2	1	2	2	1	-	-	-	2	2
CO5	3	2	2	-	1	1	2	1	2	-	-	-	2	2
CO6	2	2	3	-	3	2	2	2	1	-	-	-	2	2

Syllabus:

OVERVIEW & INSTRUCTIONS : Eight ideas — Components of a computer system — Technology – Performance – Power wall – Uniprocessors to multiprocessors; Instructions – operations and operands — representing instructions — Logical operations — control operations – Addressing and addressing modes.

ARITHMETIC OPERATIONS: ALU - Addition and subtraction –Multiplication – Division – Floating Point operations – Sub word parallelism.

PROCESSOR AND CONTROL UNIT

Basic MIPS implementation – Building data path – Control Implementation scheme – Pipelining – Pipelined data path and control – Handling Data hazards & Control hazards – Exceptions.

PARALLELISM

Instruction-level-parallelism – Parallel processing challenges – Flynn's classification – Hardware multithreading – Multicore processors.

MEMORY AND I/O SYSTEMS:

Memory hierarchy - Memory technologies – Cache basics – Measuring and improving cache performance - Virtual memory, TLBs - Input/output system, programmed I/O, DMA and interrupts, I/O processors.

Reading:

1. David A. Patterson and John L. Hennessey, ―Computer organization and design‘, Morgan Kauffman / Elsevier, Fifth edition,2014.
2. V.Carl Hamacher, Zvonko G. Varanesic and Safat G. Zaky, ―Computer Organisation―, VI edition, Mc Graw-Hill Inc,2012.
3. William Stallings ―Computer Organization and Architecture‖, Ninth Edition, Pearson Education,2013.
4. Vincent P.Heuring,Harry F.Jordan,―Computer System Architecture ‖,Second Edition, Pearson Education,2005.
5. John P.Hayes,―Computer Architecture and Organization‖, Third Edition, TataMcGrawHill,1998

Course Code: EV317	Semiconductor Device Modelling	Credits 30-0:3

Pre-Requisites: None

Course Outcomes:

CO-1	Develop mathematical models for modern MOS devices.
CO-2	Develop solution to overcome short channel issues.
CO-3	Develop various compact models appropriate for industry.
CO-4	Analyse current distribution in the devices like transistors, MOS devices.

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	-	-	-	-	-	-	-	-
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:

Semiconductors in Equilibrium and Carrier Transport, Semiconductor Materials, Carrier Concentration, Carrier Drift, Carrier Diffusion, Generation and Recombination Process, Continuity Equation, Thermionic Emission, Tunnelling, Ballistic Transport, High Field Effects.

Physics of Junction Devices: Thermal Equilibrium Condition, Depletion region, Depletion, and Diffusion Capacitances, Current-Voltage characteristics, Charge Storage and Transient behavior, Junction Breakdown, Metal Semiconductor Contacts, forward and reverse-biased junctions, reverse bias breakdown, transient, and a-c conditions.

Physics of Bipolar devices: Transistor action, Static Characteristics, minority carrier distribution and terminal currents, generalized biasing, secondary effects, Frequency Response and Switching, Semiconductor Heterojunctions.

Field-Effect Transistors: JFET- current-voltage characteristics, effects in real devices, high frequency and high-speed issues, Metal Insulator Semiconductor FET.

MOSFET: Energy band diagram in equilibrium and under bias, Flat band voltage, Potential Balance and charge balance, Effect of gate body voltage on surface condition, Accumulation and depletion, Inversion, CV Characteristics, Frequency response, threshold voltages, output and transfer characteristics of MOSFET, short channel and Narrow width effects.

SPICE Models for Semiconductor Devices: MOSFET Level 1, Level 2 and level 3 model, Model parameters; SPICE models of p-n diode and BJT.

Learning Resources:

Text Books:

1. B. G. Streetman and S. Banerjee, *Solid State Electronic Devices*, 6th Edition, PHI Private Limited, 2011.
2. P. Bhattacharya, *Semiconductor Optoelectronics Devices*, 2nd Edition, PHI, 2009.
3. G. Massobrio and P. Antognetti, *Semiconductor Device Modeling with SPICE*, 2nd Edition, TMH, 2010.
4. E. Takeda, Hot-carrier Effects in MOS Trasistors, Academic Press, 1995.
5. J. P. Colinge, "FinFETs and Other Multi-Gate Transistors," Springer. 2009

Reference Books:

1. S. M. Sze, Physics of Semiconductor Devices, (2e), Wiley Eastern, 1981.
2. M. Lundstrom, Fundamentals of Nanotransistors, World Scientific Publishing Co Pte Ltd 2017.
3. Y. P. Tsividis, Operation and Modelling of the MOS Transistor, McGraw-Hill, 1987

Other Suggested Readings:

1. https://nptel.ac.in/courses/117106033

Course Code: EV318	Flexible Electronics	Credits 30-0:3

Pre-Requisites: None

Course Outcomes:

CO-1	Identify the advantages, drawbacks, performances, complementarity, and uniqueness of large-area manufacturing versus silicon technology.
CO-2	Integrate the operation principles, architectures, and processing of main devices and systems fabricated for flexible electronics.
CO-3	Predict system integration issues and propose methods for integration and encapsulation of printed devices and systems.
CO-4	Learn about structure and properties of materials for flexible electronics

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	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2	2	2	2	2	3	-	-	-	-	-	-	-	1	-
CO-3	3	2	2	3	3	-	-	-	-	-	-	-	1	-
CO-4	2	-	-	-	-	-	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to Flexible and Printed Electronics: Evolution of Flexible Electronics, review of cutting-edge research on electronics that can be flexible, plastic, stretchable, conformable or printed. Electronic materials, components, and systems, applications for IoT.

Materials, Processing, and Manufacturing: Various semiconductors, dielectric, and conducting materials, Organic semiconductors, from chemical bonds to bands, Charge injection and transport, Examples of printable functional materials, Thin-film Deposition and Processing Methods for Flexible Devices, Solution-based Patterning Processes; Ink-jet printing, gravure, and other processes, surface energy effects, multilayer patterning.

Flexible Thin-Film Transistors and Circuits: Thin-Film Transistor; Device structure and performance, Electrical characteristics, parameter extraction, characterization methods for rigid and flexible devices, electrical stability, printed transistors; organic/polymer, metal-oxide, electrolyte gated, Case studies; sub micrometer OTFTs and gravure printed OTFTs, From transistors to circuits.

Circuits on flexible and non-silicon substrates, Contacts, and Interfaces to Organic and Inorganic Electronic Devices: Schottky contacts, defects, carrier recombination, the effect of applied mechanical strain.

Other Flexible Devices and System Integration: Organic Light Emitting Diodes, Organic Solar Cells, thin flexible OLED displays, OLED lighting, smart wallpaper, sensors, logic, and memory, RFID tags, Latest applications of printed electronics, Encapsulation, roll to roll printing processes, Integration Issues, and Designs for the Future.

Learning Resources:

Text Books:

1. G. Nisto, D. Lupo, S. Ganz, Organic and Printed Electronics Fundamental and Applications, CRC press, 2016.
2. M. M. Hussain and N. El-Atab, Handbook of Flexible and Suitable Electronics, CRC press, 2020.
3. Sarbicsoloman, 3D Bioprinting Revolution, Khanna Publishing House, 2020.

Reference Books:

1. Mario Caironi and Yong Yuong Nob, Large Area and Flexible Electronics, Wiley VCH, 2015.
2. Wong, Williams S, and Alberto Salleo, “Flexible Electronics: materials and applications”, vol 11, Springer, 2009.

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Dept. Elective-II

Course Code: EC365	RFIC DESIGN	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Understand the design bottlenecks specific to RF IC design, linearity related issues, ISI.
CO2	Identify noise sources and develop noise models for the devices and systems.
CO3	Specify noise and interference performance metrics like noise figure, IIP3 and different matching criteria.
CO4	Comprehend multiple access techniques, wireless standards and various transceiver architectures.
CO5	Design various constituents' blocks of RF receiver front end.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	3	-	1	-	-	1	-	-	-	3	2	2
CO2	2	-	2	-	1	1	-	-	-	-	-	2	2	2
CO3	1	-	3	-	2	1	-	1	-	-	-	1	2	2
CO4	-	-	1	-	1	-	-	-	-	-	-	3	2	2
CO5	1	-	2	-	3	-	-	-	-	-	-	-	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

INTRODUCTION TO RF AND WIRELESS TECHNOLOGY: Complexity comparison, Design bottle necks, Applications, Analog and digital systems, Choice of Technology.

BASIC CONCEPTS IN RF DESIGN: Nonlinearity and time variance, ISI, Random process and noise, sensitivity and dynamic range, passive impedance transformation.

MULTIPLE ACCESS: Techniques and wireless standards, mobile RF communication, FDMA, TDMA, CDMA, Wireless standards.

TRANSCEIVER ARCHITECTURES: General considerations, receiver arch itecture, Transmitter Architecture, transceiver performance tests, case studies.

AMPLIFIERS, MIXERS AND OSCILLATORS: LNAs, down conversion mixers, Cascaded Stages, oscillators, Frequency synthesizers.

POWER AMPLIFIERS: General considerations, linear and nonlinear Pas, classification, High Frequency power amplifier, large signal impedance matching, linearization techniques.

Text Books:

1. BehzadRazavi, RF Microelectronics Prentice Hall of India,2nd Edition, 2011
2. Thomas H. Lee, The Design of CMOS Radio Integrated Circuits, Cambridge University Press2nd Edition, 2003.

Course Code: EV366	Devices for Microwave Engineering	Credits 30-0:3

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the requirements of RF devices for IC designing
CO-2	Apply the principles of heterojunctions physics for RF technology
CO-3	Develop a solid understanding of Bipolar RF devices, S-parameters, smith charts, and the principles of impedance matching and RF device packaging
CO-4	Acquire technical expertise in the operation, characteristics and applications of Gun diodes and IMPATT devices

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	-	-	-	-	-	-	-	-	-	1	-
CO-2	2	2	2	-	-	-	-	-	-	-	-	-	2	1
CO-3	2	2	2	1	-	-	-	-	-	-	-	-	2	-
CO-4	2	2	3	1	-	-	-	-	-	-	-	-	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to the course: perspective & historical overview, Applications of various RF devices today,Basics of heterojunctions and heterostructure physics, Basics of III-nitrides and polarization Schottky multipliers & varactors

Transferred Electron Devices: Gunn Diode, Avalanche Transit Devices: IMPATT
III-V MESFET: physics and transport, I-V, load line, transconductance, fabrication. Intro to JFOM. III-V HEMT/MODFET – physics, modulation doping & the formation of 2DEG, breakdown, gain, traps, dispersion. p-HEMT, recess gate, field-plate, power cell, multi-finger devices, fabrication. GaN HEMTs – benefits of WBG, various aspects of GaN RF HEMT such as substrate, processing, dispersion & virtual gate, leakage, stack design, compensation doping.

Basics of RF CMOS; LDMOS – device physics, transport, breakdown, On resistance, snapback. LDMOS - layout & design, bond pad manifold, frequency aspects, the concept of RESURF.

Bipolar devices for RF: working of HBT, Early Effect, Kirk Effect, Gain, Common Emitter & Common Base mode, small-signal model.

Bipolar devices: base design, collector design, emitter ballast, SiGe bipolar, FET vs bipolar for RF, fabrication

Microwave concepts for devices and packaging: S-parameters & 2-port analysis, concept of impedance, Intro to Smith chart, de-embedding parasitics, derivation of cut-off frequencies and MAG/MSG, Transmission lines & waveguides, concept of impedance matching, Basics of RF device packaging and thermal management.

Learning Resources:

Text Books:

1. Umesh Mishra &Jasprit Singh, Semiconductor Device Physics and Design, Springer, 2014.

2. John Walker, Handbook of RF and Microwave Power Amplifiers, Cambridge University Press, 2011.

Reference Books:

1. Tobias Eribacher, Lateral Power Transistors in Integrated Circuits, Springer, 2014.
2. S. M. Sze and Kwok k. Ng, Physics of Semiconductor Devices, Wiley, 2015.

Other Suggested Readings:

1. NPTEL videos (https://nptel.ac.in/courses/108108377)

Course Code: EV367	Antennas	Credits 3-0-2: 4

Pre-Requisites: None

Course Outcomes:

CO1	Provide an understanding of antenna radiating principle and discuss the fundamental characteristics and parameters of antennas.
CO2	Develop the performance characteristics of antennas arrays, its operating principles, methods and concepts to design.
CO3	Simulation and Measurement of antenna parameters.
CO4	Understand the behavior of nature on EM wave propagation.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3						2						2	
CO2		2				1	1						2	2
CO3			2			1							2	2
CO4	3	1	1	1	1								2	

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.

Learning Resources:

Text Books:

1. E.C. Jordan & K.G. Balmain, Electromagnetic waves & Radiating Systems, PHI, 2007.

2. Antenna Theory: Analysis and Design – Constantine A. Balanis, John Wiley & Sons, 2009, 3 rd Ed.

Reference Books:

1. John D. Kraus, Antennas, McGraw Hill, 1988, 2nd Edition.
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.

Online Resources:

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/

Course Code: EV368	Semiconductor Optoelectronics	Credits 3-0-0:3

Pre-Requisites: None

Course Outcomes:

CO-1	Evaluate the properties of semiconductor optoelectronic materials and heterostructures
CO-2	Demonstrate the principles of photon interaction and stimulated emission
CO-3	Design Light emitting devices and Lasers
CO-4	Analyze the performance of semiconductor photo detectors and photonic integrated circuits

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	-	-	-	-	-	-	-	-	-	-	-	-
CO-2	1	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-3	3	2	3	1	-	-	-	-	-	-	-	-	3	-
CO-4	3	3	3	3	2	-	-	-	-	-	-	-	3	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Review of Semiconductor Device Physics: Energy bands in solids, the E-k diagram, Density of states, Occupation probability, Fermi level, and quasi-Fermi levels, p-n junctions, Schottky junction, and Ohmic contacts. Semiconductor optoelectronic materials, Bandgap modification, Heterostructures, and Quantum Wells.

Interaction of photons with electrons and holes in a semiconductor: Rates of emission and absorption, Condition for amplification by stimulated emission, the laser amplifier.

Semiconductor Photon Sources: Electroluminescence. The LED: Device structure, materials and characteristics. The Semiconductor Laser: Basic structure, theory, and device characteristics, direct current modulation, Quantum-well lasers; DFB-, DBR- and vertical-cavity surface-emitting lasers (VCSEL), Laser diode arrays, Device packages, and handling.

Semiconductor Optical Amplifiers & Modulators: Semiconductor optical amplifiers (SOA), SOA, characteristics and some applications, Quantum-confined Stark Effect and Electro-Absorption Modulators.

Semiconductor Photodetectors: Types of photodetectors, Photoconductors, Single junction under illumination: photon and carrier-loss mechanisms, Noise in photodetection; Photodiodes, PIN diodes, and APDs: structure, materials, characteristics, and device performance. Photo-transistors, solar cells, and CCDs. Optoelectronic integrated circuits – OEICs

Learning Resources:

Text Books:

1. B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, John Wiley & Sons, Inc., 2 nd Ed.2007.
2. G. Ghione, Semiconductor Devices for High-Speed Optoelectronics, Cambridge University Press (2009)
3. Yariv and P. Yeh, Photonics: Optical Electronics in Modern Communication, Oxford University Press (2007), 6 th Ed.

Reference Books:

1. G. Keiser, Optical Fiber Communications, McGraw-Hill Inc., 3 rd Ed. (2000)
2. P. Bhattacharya, Semiconductor Optoelectronic Devices, Prentice Hall of India 1995.
3. J. Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc. 1995

Other Suggested Readings:

1. NPTEL Course

Dept. Elective-III

Course Code: EC415	ELECTRONIC PACKAGING	Credits 3-0-0: 3

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

CO1	Understand the role of packaging in the computer, telecommunication, automotive, medical and consumer electronics industry
CO2	Learn the fundamentals of electrical packaging design, design for reliability, thermal management
CO3	Analyze the performance of various TSVs for 3-D ICs
CO4	Identify the packaging materials with their appropriate properties

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	3			2	2				1	2	2	
CO2	3	3	3	2		2	1				1	2	2	
CO3	3	3	3	3	3						1	2	2	1
CO4	3	3	3	3		2	1				1	2	2	1

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

Reference Books:

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

Online Resources:

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

Course Code: EC417	Computer Vision	credits 3-0-0:3

Prerequisites: None

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

CO1	Development of algorithms and techniques to analyze and interpret the visible world.
CO2	Apply feature extraction methods for computer processing.
CO3	Implement pattern recognition algorithms for real world problems
CO4	Design of face detection and recognition algorithms

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	-	3	2	-	-	1	-	-	-	-	2	2
CO2	3	3	3	2	2	2	-	2	-	-	-	-	2	2
CO3	3	3	3	3	3	-	-	-	2	-	-	-	2	2
CO4	2	3	2	2	2	2	-	2	2	-	-	-	2	2

Detailed Syllabus:

Digital Image Formation and Low-level processing: Overview and State-of-the-art, Fundamentals of Image Formation, Transformation: Orthogonal, Euclidean, Affine, Projective, etc; Fourier Transform, Convolution and Filtering, Image Enhancement, Restoration, Histogram Processing.

Digital Image Formation: Overview and State-of-the-art, Fundamentals of Image Formation, Transformation: Orthogonal, Euclidean, Affine, Projective, etc; Fourier Transform, Convolution and Filtering, Image Enhancement, Restoration, Histogram Processing

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.

sPattern 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 Educatio, 4th Edition,2017.

References:

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

Online Resources:

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/

Course Code: EV418	VLSI Interconnects	Credits 3-0-0:3

Pre-Requisites: None

Course Outcomes:

CO-1	Get an insight on transmission line parameters of VLSI interconnects
CO-2	Understand the novel solutions on future VLSI Interconnects
CO-3	Analyze the effect of crosstalk and parasitics in VLSI interconnects
CO-4	Analyze the performance of various VLSI interconnects

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	-	-	-	-	-	-	-	-	-
CO-2	3	1	3	-	-	-	-	-	-	-	-	-	1	-
CO-3	3	3	2	3	3	-	-	-	-	-	-	-	-	-
CO-4	3	3	3	2	3	-	-	-	-	-	-	-	2	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to VLSI Interconnects. Distributed RC interconnect model, Elmore delay, Elmore delay in interconnects, Elmore delay in RC tree and branched interconnects.

Equivalent circuit of RC interconnect, Scaling Effects, Delay mitigation in RC interconnects, RC interconnect simulation session, Inductive effects in interconnects.

Distributed RLC Interconnect model (Frequency domain analysis), Transmission line equations. When to consider the inductive effects?, The transfer function of an interconnect, Time-domain response of a lumped model RLC circuit.

Equivalent Elmore model for RLC interconnects (Distributed model), Two-pole model of RLC interconnects from ABCD parameters. Simulation of RLC interconnects. Origin of the skin effect, Effective resistance at high frequencies.

Equivalent circuit to simulate skin effect, Power dissipation due to interconnects, Optimum interconnect width for minimizing total power dissipation. Heating effects and thermal modelling,

Compact Thermal modeling with equivalent electrical circuit.

Electromigration in interconnects, Mitigation of electromigration. Capacitive coupling in interconnects. Cross-talk and timing jitters in two identical interconnects. Effects of cross-talk and timing jitters. Techniques for mitigation of cross-talk, Analysis of coupled interconnects, Simulation of RC coupled interconnects, Extraction of capacitance, Extraction of inductance, Estimation of interconnect parameters from S parameters, Future VLSI Interconnects.

Learning Resources:

Text Books:

1. High-Speed VLSI Interconnects, Ashok K. Goel, 2007.
2. Advanced Nanoscale ULSI Interconnects: Fundamentals and Applications, Y.S. Diamand, 2009.

.

Reference Books:

1. Carbon nanotube and Graphene Device Physics, H.S Philip Wong and Deji Akinwande, 2011.
2. Related research papers.

Other Suggested Readings:

1. NPTEL Courses (https://nptel.ac.in/courses/108105187)
2. MIT Open Course Ware, etc.

Course Code: EV419	On Chip Sensors and Interfacing Circuits	Credits 30-0:3

Pre-Requisites: CMOS Analog IC Design

Course Outcomes:

CO-1	Understand the sensor parameters
CO-2	Design of temperature and capacitive sensors
CO-3	Evaluate different frontend ICs for sensor circuits and design for given specifications
CO-4	Comprehend the noise issues in sensors and it's circuits

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	3	-	-	-	-	-	-	-	-	2	-
CO-2	2	1	1	1	2	-	-	-	-	-	-	-	-	-
CO-3	1	2	3	2	2	-	-	-	-	-	-	-	3	-
CO-4	3	1	1	1	-	-	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Characterization of sensors: Definitions, terminology, classification, Static vs dynamic properties of transducers, Transfer functions, Ideal and realistic transducer models. Resolution, linearization, dynamic range, detection threshold, Selectivity & sensitivity, Calibration, Errors of the experimental measurements. Physical Principle of Sensing: Resistance, Capacitance, Piezoelectric effect, Pyroelectric effect, Thermal and Optical phenomenon.

Temperature Sensors: Basic concepts, Temperature scale, standard temperature points, Thermistor sensors, Thermocouple Sensors, The pyrometer, radiation thermometer, pressure thermometer liquid and gaseous, Temperature sensor applications

Capacitive sensors: Various design considerations; guarding, stray fields, offset and stray capacitance, Ratio metric measurement, circuit implementations. Synchronous Phase Detection – multiplier and switching type, Capacitive Angle Transducers

Front end interface circuits: Signal Conditioners: Input Characteristics, Amplifiers, Charge-and Current-to-Voltage Converters, Light-to-Voltage Converters, Capacitance-to-Voltage Converters, Null-Balanced bridge, Bridge Amplifiers, Excitation Circuits, ADC for sensor data, PWM Converters.

Noise in Sensors and Circuits: Inherent Noise, Transmitted Noise, Electric Bypass Capacitors, Magnetic Shielding, Mechanical Noise, Ground Planes, Ground Loops and Ground Isolation, See beck Noise

Learning Resources:

Text Books:

1. Jacob Fraden, (2016), Handbook of Modern Sensors, 5th Edition, Springer.
2. Ramón Pallás-Areny, John G. Webster, Sensors and Signal Conditioning, 2nd Edition, Wiley, 2003.
J. G. Webster, The Measurement, Instrumentation and Sensors Handbook, Vol 1 and 2, CRC Press, 1999

Reference Books:

1. Doebelin, E.O., Measurement systems: Application and Design, 5th ed., McGraw hill, 2003

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Dept. Elective-IV

Course Code: EC419	FPGA Design	Credits 3-0-0:3

Pre-Requisites: None

Course Outcomes:

CO-1	Understand FPGA design flow.
CO-2	Identify the building blocks of commercially available FPGA/CPLDs.
CO-3	Develop VHDL/Verilog models and synthesize targeting for & series FPGA Devices.
CO-4	Design an SoC targeting Zynq 7000 series device.

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	2	-	1	-	2	-	-	-	-	-	-	-	-	-
CO-3	2	2	2	1	3	-	-	-	-	-	-	-	2	-
CO-4	3	2	3	3	3	-	-	-	-	-	-	-	2	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

INTRODUCTION TO FPGAs: Evolution of programmable devices, FPGA Design flow, Applications of FPGA, Review of building blocks of Xilinx FPGA devices XC3000, XC4000: LUT, dedicated carry logic, I/O Block and Programmable Interconnect.

Xilinx FPGAs: Programming Technologies, features of commercially available Xilinx FPGAs: Xilinx 7 Series devices, Xilinx Ultra scale devices.

Xilinx Zynq 7000 series devices: Features and different technologies employed in developing these Architectures Building blocks of 7 Series FPGAs: different resources for mapping the functionality modelled using HDL Configurable Logic blocks, Block RAM, DSP blocks, Input-output blocks, High speed transceivers, Routing structures, Clock resources.

Building blocks of Ultra scale FPGAs: Configurable Logic blocks, Input-output blocks, UltraScale architecture configuration.

Building blocks of Xilinx Zynq 7000 series devices: Application Processor Unit (APU), cache, External Memory Interfaces, I/O Peripherals and Interfaces, Interconnect, Configurable Logic blocks, Programmable I/O Blocks, JTAG Boundary-Scan, Serial Transceivers, PCI Express® Block, Two 12- Bit Analog-to-Digital Converters.

Deisgn Examples using Xilinx FPGA: 32-bitAdder architectures, multiplier Architectures, 32-bit MIPS processor with a few DSP and Multimedia Instructions

Learning Resources:

Text Books:

1.John V. Old Field, Richrad C. Dorf, Field Programmable Gate Arrays, Wiley, 2008.

2. Stephen D. Brown, Robert J. Francis, Jonathan Rose, Zvonko G. Vranesic, Field Programmable Gate Arrays, 2nd Edition, Springer, 1992.

Reference Books:

1. Data sheets of Artix-7, Kintex-7, Virtex-7

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: EC421	OPTIMIZATION TECHNIQUES	Credits 3–0–0:3

Pre-requisites: Nil

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

CO1	Able to formulate mathematical models of real world problems
CO2	Understand the major limitations and capabilities of deterministic operations
CO3	Handle, Solve and analyze problems using linear programming and other mathematical programming algorithms
CO4	Solve various multivariable optimization problem

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	2	2	2
CO2	3	-	-	-	-	-	-	-	-	-	-	-	2	2
CO3	3	-	-	-	-	-	-	-	-	-	-	-	2	2
CO4	3	-	-	-	-	-	-	-	-	-	-	-	2	2

Detailed 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-pth 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 (TLBO), 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

4. S Rajasekharan, G.A Vijaya Lakshmi Pai, Neural Networks, Fuzzy logic, and Genetic algorithms, Synthesis and Applications, Prentice hall of India, 2007

5. Weifan Wang, Xuding Zhu, Ding-Zhu Du, Combinatorial Optimization and Applications:5th International Conference, Springer Publications, 2011

Course Code: EV422	Nanoelectronics	Credits 3-0-0:3

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the physics and materials for Nanoelectronics
CO-2	Understand the scaling issues
CO-3	Explain the need for non-classical and non-silicon based devices
CO-4	Analyze the performance of novel devices

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	3	-	1	-	-	-	-	-	-	-	-	-	-	-
CO-3	3	-	1	1	-	-	-	-	-	-	-	-	-	-
CO-4	3	3	3	3	3	-	-	-	-	-	-	-	1	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Overview: Nanodevices, Nano materials, Nano characterization, Definition of Technology node, Basic CMOS Process flow, MOS Scaling theory, Issues in scaling MOS transistors: short channel effects, Description of a typical 65 nm CMOS technology. Requirements for Nonclassical MOS transistor, MOS capacitor, Role of interface quality and related process techniques, Gate oxide thickness scaling trend, SiO2 vs High-k gate dielectrics. Integration issues of high-k Interface states, bulk charge, band offset, stability, reliability – Qbd high field, possible candidates, CV and IV techniques.

Metal gate transistor: Motivation, requirements, Integration Issues, Transport in Nano MOSFET, velocity saturation, ballistic transport, injection velocity, velocity overshoot. SOI - PDSOI and FDSOI, Ultrathin body SOI – double gate transistors, integration issues, Vertical transistors - FinFET and Surround gate FET, Metal source/drain junctions – Properties of Schottky junctions on Silicon, Germanium, and compound semiconductors-Work function pinning.

Germanium Nano MOSFETs: strain, quantization, Advantages of Germanium over Silicon, PMOS versus NMOS. Compound semiconductors – material properties, MESFETs Compound semiconductors MOSFETs in the context of channel quantization and strain, Heterostructure MOSFETs exploiting novel materials, strain, quantization.

Learning Resources:

Text Books:

1. Y. Taur and T. Ning, “Fundamentals of Modern VLSI devices” Cambridge University Press
2. Nicollian and J. R. Brews “MOS (Metal Oxide Semiconductor) Physics and Technology” Wiley Publishers

Reference Books:

1. Brundle, C.Richard; Evans, Charles A. Jr.; Wilson, Shaun “Encyclopedia of Materials Characterization”, Elsevier.
2. Supriyo Datta, Lessons from Nanoelectronics A new Prospective on transport – Part A: Basic Concepts, World Scientific, 2017.

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: EV423	Heterojunction Device Physics	Credits 3-0-0:3

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the band structure of heterojunction devices
CO-2	Analyze the electrical behavior of 2D heterojunctions
CO-3	Understand the density of states in different dimensional structures like 0D, 1D, 2D and 3D
CO-4	Analyze the transport mechanisms in heterojunction devices

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	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Semiconductor abrupt junctions, Equilibrium conditions, the contact potential, space charge at a semiconductor junction, qualitative description of current flow at a junction, minority, and majority carrier currents, carrier injection, minority carrier distributions, variation of the quasi-Fermi levels with the position, junction current from excess minority carriers, junction breakdown mechanisms, capacitance of p-n junctions.

Semiconductor heterojunctions: Types of heterojunctions, energy band diagrams of hetero structures, current-voltage and, capacitance-voltage characteristics of anisotype heterojunctions, hetero junction bipolar transistors, electrical and optical characteristics of LEDs, laser gain semiconductor band system, high electron mobility transistor, hot electron heterojunction transistor.

2D electron gas and Quantum wells: 2D electron gas in Si and GaAs MOS structures, effect of applied bias on energy bands of the MOS capacitors, bias dependence of capacitance, free charge carrier transfer. Triangular quantum wells (both finite and infinite), coupled quantum wells, and superlattices, double heterostructure lasers, single quantum well lasers, multiple quantum well lasers. Optical absorption due to electronic transitions in quantum wells.

T**ransport properties of heterostructures and quantum devices**: Effect of electric field parallel and perpendicular to the interfaces, effects of constant magnetic field, Landau levels, magnetoconductivity in a 2D heterostructure. One-D and Zero-D quantum structures.

The density of states in 3D, 2D, 1D and 0D structures: 1D and 0D optical phenomena and optical devices, quantum confined stark effect, quantum well modulators, self-electro-optic effect devices, resonant tunneling devices, the coulomb blockade, single electron transistor.

Learning Resources:

Text Books:

1. B. L. Sharma and R. K. Purohit, Semiconductor Heterojunctions, Pergamon press, 2015.
2. A. R. Milnes and D. L. Hnech, Heterojunction and metal semiconductor junctions, Academic Press.

Reference Books:

1. B. G. Streetman Solid state electronic devices, Prentice Hall India Learning Private Limited,2006, 6thEdition.
2. M. Balkanski and R. F. Walls, Semiconductor Physics and applications, Oxford university press, 2000.

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Dept. Elective-V

Course Code: EC424	IPR & CYBER LAWS	Credits 3-0-0: 3

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

CO1	Explain origin and development of IPRs
CO2	Understand the economic importance of IPRs
CO3	Understand the international development of cyber laws
CO4	Understand the relation between IPR and Cyber laws

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1						2		1				1		
CO2						2		2	1	2	1	1	1	2
CO3						1	1	1			1	1		
CO4						1		2	1	1		1		2

Detailed Syllabus:

IPR

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 Laws

Conceptual and theoretical perspective of Cyber Law - Computer and Web Technology - Development of Cyber Law – National and International Perspective Cyber Law - Legal Issues and Challenges in India, Web Content Accessibility Guidelines (WCAG). Information Technology Act, 2000 - Overview of the Act – Jurisdiction -Electronic Governance – Electronic Evidence - Digital Signature Certificates - Digital signatures - Internet Service Providers and their Liability – Powers of Police - Impact of the Act on

other Laws – Social Networking Sites Vis-àvis Human Rights.

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:

References:

1. Ananth Padmanabhan, Intellectual Property Rights: Infringement and Remedies, LexisNexis, 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., 5e, 2018.
4. Paul Torremans, Holyoak & Torremans Intellectual Property Law, Oxford Univ.Press, 2010
5. Justice Yatindra Singh, Cyber Laws, Universal Law Publishing, UP, 2016.
6. Farouq Ahmed, Cyber Law in India, Allahabad Law Agency, 2015
7. Karnika Seth, Computers, Internet and New Technology Laws-A Comprehensive Reference Work With Special Focus On Developments In India, LexisNexis, Nagpur, 2016.
8. Kamath Nandan: Law relating to Computer, Internet and E-Commerce, Universal Law Publishing, UP, 2007.

Course Code: EC425	Cryptography and Network Security	Credits 3-0-0:3

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	-
CO-2	2	2	-	3	3	1	-	-	-	-	-	-	1	-
CO-3	-	-	3	1	1	2	-	-	-	-	-	-	1	-
CO-4	3	1	2	3	3	3	-	-	-	-	-	-	3	-

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, 6th edition Pearson Education, 2014.

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Reference Books:

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

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc

Course Code: EV426	ASIC Design	Credits 3-0-0:3

Pre-Requisites: None

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, 2ndEdition, Kluwer Academic, 2001.

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.

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.

Course Code: EV427	Reliability of VLSI Systems	Credits 3-0-0:3

Pre-Requisites: None

Course Outcomes:

CO-1	Define the reliability of electronic device and circuit
CO-2	Understand the failure mechanisms of electronic device and circuit
CO-3	Understand the concept of yield in electronic manufacturing
CO-4	Resolve the reliability issues in VLSI design
CO-5	Predict the circuit performance using reliability models

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	1	-	-	-	-	-	-	-	1	-
CO-2	3	3	1	1	1	-	-	-	-	-	-	-	1	-
CO-3	3	2	1	1	1	-	-	-	-	-	-	-	1	-
CO-4	1	1	3	2	2	-	-	-	-	-	-	-	3	-
CO-5	1	1	2	2	2	-	-	-	-	-	-	-	1	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Background and Introduction: Definitions of reliability, failure modes, mechanisms, Basic concepts –Reliability functions, Relationship between these functions – Baths tubs curve – Exponential failure density and distribution functions - Expected value and standard deviation of Exponential distribution –Measures of reliability – MTTF, MTTR, MTBF

Introduction to mathematical methods for reliability: Failure rates, Normal distribution function, Six Sigma, Exponential, Weibull and Lognormal distributions for reliability modeling. Manufacturing yields.

Physics of failure-based models for: Mass transport-induced failures (electro migration and stress voiding), Electronic charge-induced failures (Dielectric breakdown, Hot carrier effects, Electrical over-stress and Electrostatic discharge),

Circuit Performance considering NBTI, PBTI, oxide breakdown, impact of parasitic effects, process temperature variation, Electromagnetic Interference (EMI) and Electrostatic Discharge (ESD).

Introduction to semiconductor device packaging: Materials and processes used for semiconductor device packaging.

Learning Resources:

Text Books:

1. M. Ohring, Reliability and Failure of Electronic Materials and Devices, First Edition, Academic Press, 1998.
2. J.W. McPherson, Reliability Physics and Engineering, Second Edition, Springer, 2013.

Reference Books:

1. Yuan Taur and T. Ning, "Fundamentals of Modern VLSI Devices," Cambridge University Press,1998.

2. J.Ross, Microelectronic Failure Analysis, Sixth Edition, ASTM International, 2011

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc

Dept. Elective-VI

Course Code: EC466	5G Communications and MIMO	Credits 3-0-0: 3

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

CO1	Learn 5G Technology advances and their benefits
CO2	Learn the key RF, PHY, MAC and air interface changes required to support 5G
CO3	Learn Device to device communication and millimeter wave communication
CO4	Understand the Implementation options for 5G

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1				1							1	1
CO2	1	1	1										1	
CO3	1		1	1									1	
CO4	1												1	1

Detailed Syllabus:

Overview of 5G Broadband Wireless Communications: Evaluation of mobile technologies 1G to 4G (LTE, LTEA, LTEA Pro) , An Overview of 5G requirements, Regulations for 5G,Spectrum Analysis and Sharing for 5G.

RF FRONT END FOR 5G: Millimeter Wave Communications: Hardware technologies for mmW systems — Architecture and Mobility — Massive MIMO: Resource allocation and transceiver algorithms for massive MIMO - Fundamentals of baseband and RF implementations in massive MIMO - Beamforming.

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).

NETWORKING IN 5G: Coordinated multi-point transmission in 5G: Joint Transmission CoMP enablers - Distributed cooperative transmission - JT CoMP with advanced

receivers - Relaying and network coding in 5G: Multi-flow wireless backhauling - Buffer-aided relaying.

Device-to-device (D2D) and machine-to-machine (M2M) type communications — Extension of 4G D2D standardization to 5G, radio resource management for mobile broadband D2D, multi-hop and multi-operator D2D communications.

Millimeter-wave Communications — spectrum regulations, deployment scenarios, physical layer techniques, interference and mobility management, Massive MIMO propagation channel models, Channel Estimation in Massive MIMO, Massive MIMO with Imperfect CSI, Multi-Cell Massive MIMO, Pilot Contamination, Spatial Modulation (SM),

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.

2. AfifOsseiran, Jose.F.Monserrat, Patrick Marsch, —Fundamentals of 5G Mobile Networks‖ , Cambridge University Press.

3. Athanasios G.Kanatos, Konstantina S.Nikita, Panagiotis Mathiopoulos, —New Directions in Wireless Communication Systems from Mobile to 5G‖, CRC Press.

4. Wei Xiang, Kan Zheng, Xuemin(Sherman) Shen, - 5G Mobile Communications, Springer, 2017.

5. Theodore S.Rappaport, Robert W.Heath, Robert C.Danials, James N.Murdock —Millimeter Wave Wireless Communications‖, Prentice Hall Communications.

References :

1. Jonathan Rodriguez, —Fundamentals of 5G Mobile Networks‖, John Wiley & Sons.

2. Amitabha Ghosh and Rapeepat Ratasuk—Essentials of LTE and LTE-A‖, Cambridge University Press.

Course Code: EC468	Hardware-Software Co-Design	Credits 3-0-0:3

Prerequisites: None

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

CO1	Understand Hardware/Software Co-design
CO2	Model the data flow and implement the same through software and hardware.
CO3	Design the Control Flow on Transistor Structures
CO4	Understand the design principles in SoC Architecture
CO5	Design CORDIC and Crypto coprocessor.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1					2		2			1		1	2	
CO2					2	1	2					2	2	
CO3					2		3			1		1	2	
CO4					2	1	2					2	2	
CO5					2		1			1		2	2	

Detailed 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.

FiniteState Machine with Datapath: 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:

TextBooks:

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

Online Resources:

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

Course Code: EV469	High Speed Interfacing Circuits	Credits 3-0-0:3

Pre-Requisites: None

Course Outcomes:

CO-1	Identifying the challenges of high speed interfacing circuits
CO-2	Understand the concepts of ser-des
CO-3	Develop high speed serial communication architectures
CO-4	Understand signal integrity issues and develop power efficient solutions

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	3	-	-	-	-	-	-	-	-	2	-
CO-2	2	1	1	1	2	-	-	-	-	-	-	-	-	-
CO-3	1	2	3	2	2	-	-	-	-	-	-	-	3	-
CO-4	3	1	1	1	-	-	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

SerDes Transceiver for High-Speed Serial Communications, Design challenges, Circuit Styles, PISO and SIPO, Clock Multiplier Unit, Equalization, Data and Clock Recovery

Serdes Concepts: Source Synchronous Interfaces, High-Speed Serdes, Signal Integrity, Signaling Methods, HSS features and functions: HSS Core Example: HSS EX10 10-Gbps Core, HSS EX10 Transmitter Slice Functions, HSS EX10 Receiver Slice Functions, Phase- Locked Loop (PLL) Slice, Reset and Reconfiguration Sequences.

HSS Architecture and Design: Phase Locked Loop (PLL) Slice, Transmitter Slice, Receiver Slice. Reference Clocks: Clock Distribution Network, Clock Jitter, Clock Floor-planning, Signal Integrity of the Clock Network, Signal Integrity: Probability Density Functions, Jitter, Statistical Approach to Signal Integrity. Power Analysis: Digital and non-digital Logic Circuits, HSS power, Reducing Power Dissipation

Learning Resources:

Text Books:

1. "High Speed SerDes Devices and Applications" by David R. Stauffer, Jeanne Trinko Mechler, Michael Sorna, Kent Dramstad, Clarence R. Ogilvie, Amanullah Mohammad and James Rockrohr,

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc

Course Code: EV470	Introduction to Quantum Computing	Credits 3-0-0:3

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the principles of quantum computation qubit
CO-2	Analyze multi-qubit systems and protocols
CO-3	Apply quantum measurement and entanglement concepts
CO-4	Design and implement quantum algorithms and circuits

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	-	-	-	-	-	-	-	-	-	-	-	-
CO-2	3	3	1	1	3	-	-	-	-	-	-	-	-	-
CO-3	3	3	2	1	3	-	-	-	-	-	-	-	3	2
CO-4	3	3	3	3	3	-	-	-	-	-	-	-	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Review of Quantum Mechanics and Motivation for Quantum Computation Qubit: The qubit state - matrix and Bloch sphere representation - computational basis unitary evolution.

Multi-qubit states - No-cloning theorem - Superdense coding - Pure states to Bell states – Bell inequalities. Protocols with multi-qubits: Swapping - Teleportation - gates: CNOT - Toffoli gate - NAND - FANOUT - Walsh Hadamard.

Measurement: Projective operators - General, Projective and POVM measure, Ensemble: Density operators - pure and mixed ensemble - time evolution – post measurement density operator. Composite systems: Partial trace - Reduced density operator - Schmidt decomposition, Purification bipartite entanglement.

Quantum computing: Classical computing using qubits - Quantum parallelism - Deutsch's algorithm.

Quantum circuits: Basic gates - ABC decomposition - Gray codes - Universal gates.

Learning Resources:

Text Books:

1. Quantum Computation and Quantum Information, M. A. Nielsen and I. L. Chuang, Cambridge University Press.
2. Quantum Information and Computation, CIT Lecture Notes by J. Preskill.

Reference Books:

1. Quantum Theory: Concepts and Methods, Asher Peres, Kluwer Academic Publishers.

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc

Dept. Elective-VII

Course Code: EC469	INTELLIGENT CAD	Credits 3-0-0: 3

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

CO1	Specify routing techniques in IC design.
CO2	Incorporate timing analysis and floor planning.
CO3	Design the IC with programmable structures.
CO4	Implement EDA/CAD with machine intelligence.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	3		2						1	2	2	
CO2	2	2	3	2	2						1	2	2	
CO3	2	2	3	2	3						1	2	2	
CO4	2	2	3		3						1	2	2	

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.

Online Resources:

1. https://nptel.ac.in/courses/106/105/106105161/
2. https://nptel.ac.in/courses/106/106/106106088/
3. https://nptel.ac.in/courses/106/106/106106089/

Course Code: EC472	Cloud Computing	credits 3-0-0: 3

Prerequisites: None

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

CO1	Identify the appropriate cloud services for a given application
CO2	Analyze Cloud infrastructure including Google Cloud and Amazon Cloud.
CO3	Analyze authentication, confidentiality and privacy issues in Cloud computing environment.
CO4	Determine financial and technological implications for selecting cloud computing platforms

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2	2	1	2	2	2	1	-	-	-	2	2
CO2	2	3	2	2	3	2	1	2	1	-	-	-	2	2
CO3	2	3	2	2	1	2	3	2	1	-	-	-	2	2
CO4	2	2	3	3	3	3	2	2	1	-	-	-	2	2

Detailed 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. Anothony T Velte, Toby J Velte, Robert Elsenpeter, Cloud Computing: A Practical Approach, MGH, 2010.
2. Gautam Shroff, Enterprise Cloud Computing, Cambridge, 2010.
3. Ronald Krutz and Russell Dean Vines, Cloud Security, First Edition, Wiley, 2010.

References:

1. ArshdeepBahga, Vijay Madisetti, "Cloud Computing: A Hands-on Approach", Universities Press (India) Private Limited, 2014
2. RajkumarBuyya, James Broberg, Andrzej Goscinski, "Cloud Computing Principles and Paradigms", Wiley, 2011

Online Resources:

https://nptel.ac.in/courses/106/105/106105223/

Course Code: EV473	MEMS & NEMS	Credits 3-0-0:3

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze Micro/Nano Sensors and Actuators
CO-2	Apply materials and mechanics in micro-systems design
CO-3	Design and evaluate MEMS products
CO-4	Implement microfabrication 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	3	3	3	2	3	-	-	-	-	-	-	-	3	1
CO-2	3	3	1	2	3	-	-	-	-	-	-	-	-	-
CO-3	3	3	3	3	3	-	-	-	-	-	-	-	3	3
CO-4	3	2	2	3	2	-	-	-	-	-	-	-	2	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to MEMS: Historical Background, Scaling Effects. Micro/Nano Sensors, Review of Basic MEMS fabrication modules, Oxidation, Deposition Techniques, Lithography (LIGA), and Etching. Micromachining, Surface Micromachining, sacrificial layer processes, Stiction, Bulk Micromachining, Isotropic Etching, and Anisotropic Etching, Wafer Bonding, Mechanics of solids in MEMS/NEMS.

Micro-actuators and Micro-sensors: Micro-sensors, acoustic wave sensors, biomedical and nano sensors, chemical sensors, optical sensors, pressure sensors, thermal sensors, micro-actuation through thermal forces, SMA-Piezo electric crystals, and electrostatic forces, magnetic actuation, micro-grippers, micro-motors, micro-valves, micropumps, micro-accelerometers.

Materials, Mechanics and design of micro-systems: Silicon as a substrate, compounds, piezo resistors, polymers, and packaging materials, micro-fabrication and micro-etching: static bending of thin plates, thermo mechanics and thin film mechanics.

Case studies of MEMS Products: Micro-fluidic devices, micro/nano transducers, blood pressure sensors, microphone-acceleration sensors, gyroscope, an overview of micro-system packaging.

Learning Resources:

Text Books:

1. Marc Madou, Fundamentals of Microfabrication and Nanotechnology (3 rd edition)Authors, Title of the Text Book, Name of the Publisher, Year of publication, Edition
2. Stephen D. Senturia, Microsystem Design
3. Gregory T.A. Kovacs, Micromachined Transducers.

Reference Books:

1. Guozhong Cao,Ying, Nanostructure and Nano materials, synthesis, properties and applications, World Scientific Publishing Co. 2011.
2. Chang Liu, Foundation of MEMS, Pearson Education, ISBN (978-81-317-6475-6).

Other Suggested Readings:

1. NPTEL Courses(https://nptel.ac.in/courses/117105082), MIT Open Course Ware, etc.

Course Code: EV474	Power Management IC Design	Credits 3-0-0:3

Pre-Requisites: None

Course Outcomes:

CO-1	Identify challenges of power management for analog and mixed signal circuits
CO-2	Design low dropout regulators with optimum transient response
CO-3	Develop efficient switching regulators
CO-4	Explore on-chip power management solutions for mixed signal 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	1	3	-	-	-	-	-	-	-	-	2	-
CO-2	2	1	1	1	2	-	-	-	-	-	-	-	-	-
CO-3	1	2	3	2	2	-	-	-	-	-	-	-	3	-
CO-4	3	1	1	1	-	-	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Overview of Power Management: Significance of Power Management, classification of voltage regulators, merits and demerits of linear and switching regulators, applications.

Low Drop-Out Voltage Regulators: Topologies, characterization, challenges and design of on chip LDOs.

DC-DC Converters: Principles of DC-DC converters, classification modes of operation compensation techniques.

Design considerations of regulators: PWM modulator, intricacies of error amplifier design, design of drivers, layout considerations for pass transistors, topologies to improve power supply rejection, efficiency calculations.

Power management unit design: Power management considerations for mixed signal IC, improving the efficiency of power management unit through tandem connection of DC-DC converter and LDO's

Learning Resources:

Text Books:

1. Switch-Mode Power Supplies: SPICE Simulations and Practical Designs, Christophe P Basso, BPB Publications, 2010
2. Power Management Techniques for Integrated Circuit Design By Ke-Horng Chen, Wiley-Blackwell, 2016

Reference Books:

1. Fundamentals of Power Electronics, 2nd edition by Robert W. Erickson, Dragan Maksimovic, Springer (India) Pvt. Ltd, 2005

Other Suggested Readings:

1. NPTEL Courses
2. MIT Open Course Ware, etc.