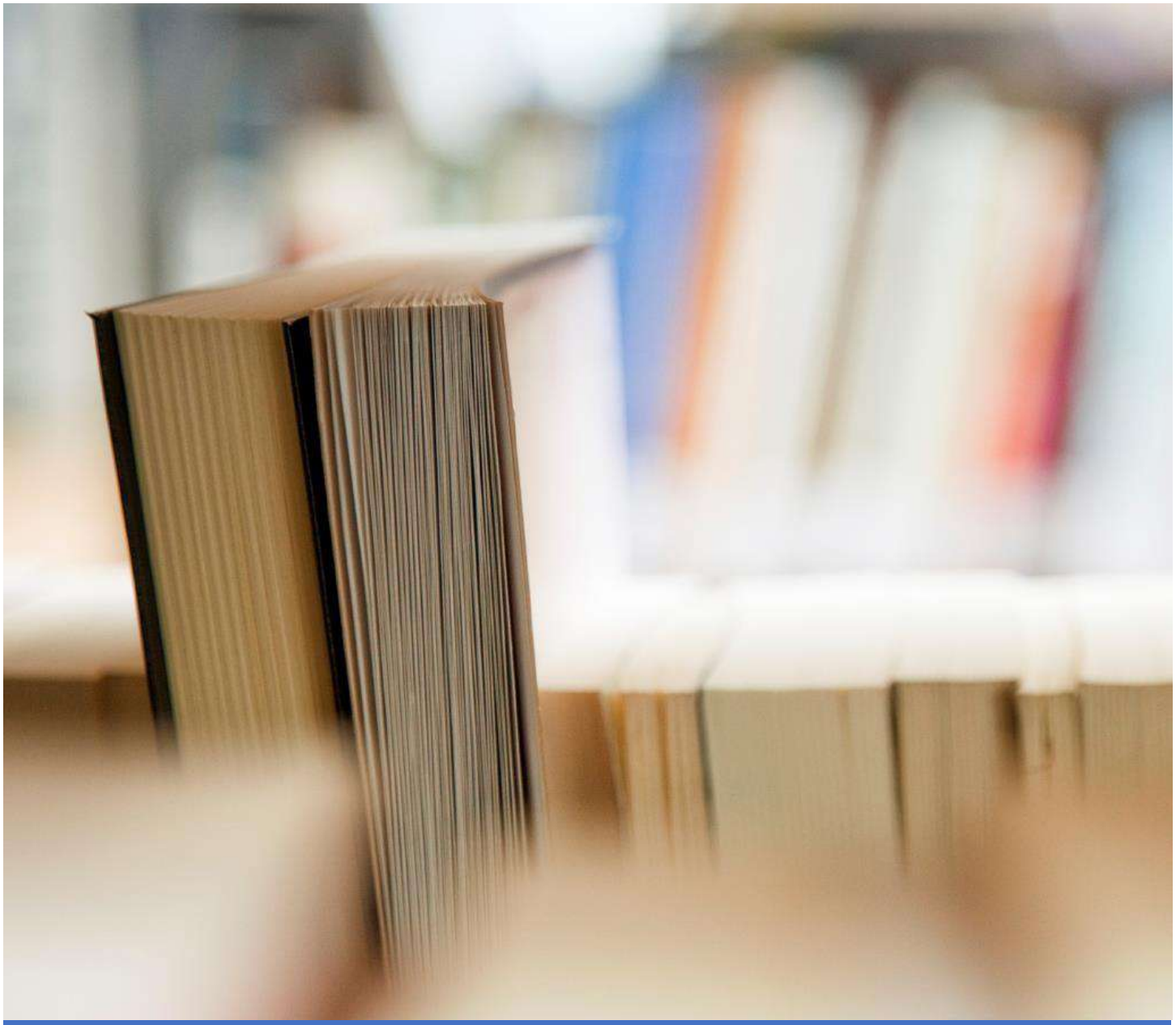
SHIV NADAR
INSTITUTION OF EMINENCE DEEMED TO BE UNIVERSITY
DELHI NCR

DEPARTMENT
OF
ELECTRICAL ENGINEERING



Prospectus (2024–2028)

Department of Electrical Engineering

Electrical and Computer Engineering
Program

Department of Electrical Engineering

School of Engineering

UG Prospectus B.Tech. ECE with Specialization

I. Overview of Department of Electrical Engineering

The Electrical Engineering (EE) department is part of the School of Engineering (SoE) at SNIoE. Its vision is to be a catalyst in imparting quality education and conducting valued research for the benefit of society. Historically, the field of electrical engineering is one of the most important engineering disciplines that have changed the course of the world. Some of our important areas of teaching are electrical machines and drives, power electronics, power systems, integrated circuits and systems, control systems, machine intelligence, communication systems and signal processing. Sufficient emphasis is given to practical teaching and hands-on learning. Relevant laboratories have been established to meet the requirements of teaching and research. The vision of the department is to establish itself as a center of excellence in terms of research and teaching in its chosen areas. We are committed to establishing human and material infrastructure towards this cause. The department has formed research groups in some of the key areas and is in the process of collaborating with various renowned institutions.

The undergraduate program is broad-based and founded on the pedagogy of learning by doing. The postgraduate programs are getting formulated and are intended to provide advanced degrees in contemporary areas of industrial relevance. They also provide platforms for research avenues. The department has a vibrant doctoral research program. The doctoral program aims to conduct research both in fundamental and applied areas for societal use. The programs intend to fill the dearth in the supply of highly skilled professionals. It will also enable the students to gain high-end skills for intellectually challenging careers in industry. Our aim is to invoke in our students a sense of curiosity to question and to motivate them to think deeply about theoretical and applied problems in technology for society’s needs.

Presently the EE department offers the following programs: -

Undergraduate Program:

Bachelor of Technology in Electrical and Computer Engineering (B. Tech. in ECE)

- with the option of doing minor in any other stream of interest.
- with the option of doing Specialization in any of the FOUR areas of interest.

Detailed rules and regulations regarding B. Tech. Program at SNIoE can be found in UG handbook (available at: https://snulinks.snu.edu.in/snuPolicies/students/

Master Programs:

(I) M. Tech in RF and Microwave Engineering
(II) M. Tech in VLSI & Embedded Systems

Doctoral Programs:

(I) Ph.D. in Electrical Engineering / Electronics and Communication Engineering

Credit Break-up of UG Curriculum in Electrical and Computer Engineering

	Total number of Credits:	163	
S. No.	**Category**	**Credits**	
1	Core Common Curriculum (CCC)	18	42
2	University Wide Elective (UWE)	18	
3	Basic Sciences (BS)	20	
4	Engineering Sciences (ES)	13	
5	Major Core	50	
6	Major Elective	29	
7	Minor Project	3	
8	Major Project / Internship	6	
	Total Credits	**163**	

Detailed Break up Semester wise and Category wise

		Engineering Science (ES)			
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**	**Semester Offered**
1	ECE101	Basics of Electrical and Electronic Circuits	3:1:1	5	1
2	CSD101	Introduction to Computing and Programming	3:0:1	4	1
3	CSD102	Data Structures	3:0:1	4	3

		Basic Sciences (BS)			
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**	**Semester Offered**
1	MAT103	Mathematical Methods I	3-1-0	4	1
2	PHY101	Introduction to Physics I	3-1-0	4	1
3	MAT104	Mathematical Methods II	3-1-0	4	2
4	PHY102	Introduction to Physics II	3-1-1	5	2
5	MAT205	Mathematical Methods III - Probability and Statistics	3-0-0	3	3

		Major Core Courses			
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**	**Semester Offered**
1	ECE103	Digital Electronics	3:1:1	5	2
2	ECE102	Semiconductor Devices	3:0:0	3	2
3	ECE201	Electric Machines & Power Systems	3-0-1	4	3
4	ECE203	Signals and Systems	3-1-0	4	3
5	ECE202	Embedded Systems Hardware	3-0-1	4	3
6	ECE205	Electromagnetic Engineering	3-1-0	4	4
7	ECE204	Analog Circuits	3-0-1	4	4
8	ECE206	Power Electronics and Machine Drives	3-0-1	4	4
9	ECE207	Principles of Communication Engineering	3-0-1	4	4
10	ECE301	Control Systems	3-0-1	4	5
11	ECE302	Digital Signal Processing	3-0-1	4	5
12	ECE303	Computer Organization and Design	3-0-0	3	5
13	ECE304	Artificial Intelligence and Machine Learning	3-0-0	3	6

S. No.	Course Code	Major Elective Courses	L:T:P	Credits	Semester Offered	Specialization
1	ECE351	VLSI Design	3:0:1	4	5	Sensors and Nano-electronics
2	ECE352	Photovoltaic Power Generation	3:0:0	3	5	Modern Energy Systems
3	ECE353	Microwave Engineering	3:0:0	3	5	Analog/RF and Communication Engineering
4	ECE354	Sensor, Measurement, and Actuators	3:0:1	4	5	1. Sensors and Nano-electronics 2. Modern Energy Systems 3. Embedded Systems and Computer Engineering
5	ECE355	Scientific Computing using MATLAB	2:0:1	3	5	Miscellaneous
6	ECE356	RF and Microwave Circuit Design	3:0:1	4	5	Analog/RF and Communication Engineering
7	ECE357	Introduction to Robotics	3:0:1	4	5	Embedded Systems and Computer Engineering
8	ECE363	Computer Communication Networks	3:0:1	4	5	1. Analog/RF and Communication Engineering 2. Embedded Systems and Computer Engineering
9	ECE370	Wireless Communications	3-0-0	3	5	Analog/RF and Communication Engineering
10	ECE457	Information Theory and Coding	3:0:0	3	5	Analog/RF and Communication Engineering
11	ECE360	IoT - Architecture, Communication Technology, and Applications	2:0:1	3	6	Embedded Systems and Computer Engineering
12	ECE361	Power System Analysis	3:0:1	4	6	Modern Energy Systems
13	ECE362	Digital Communication	3:1:1	5	6	Analog/RF and Communication Engineering
14	ECE365	Object Oriented Programming	3:0:0	3	6	Miscellaneous
15	ECE366	Antenna Theory and Wave Propagation	3:0:1	4	6	Analog/RF and Communication Engineering
16	ECE367	Digital Design with FPGAs	3:0:1	4	6	1. Embedded Systems and Computer Engineering 2. Sensors and Nano-electronics
17	ECE368	Special Topics in Microwave Engineering	3:0:0	3	6	Analog/RF and Communication Engineering
18	ECE371	Detection and Estimation	3-0-0	3	6	Analog/RF and Communication Engineering
19	ECE372	Modern Control Systems	3-1-0	4	6	1. Analog/RF and Communication Engineering 2. Modern Energy Systems
20	ECE373	Wireless Network Security	3-0-0	3	6	Analog/RF and Communication Engineering
21	ECE374	Reconfigurable Computing	3-0-0	3	6	Sensors and Nano-electronics
22	ECE375	Quantum Computing	3-1-0	4	6	1. Embedded Systems and Computer Engineering 2. Analog/RF and Communication Engineering
23	ECE451	Design of CMOS Analog Circuits	3:0:0	3	7	Sensors and Nano-electronics
24	ECE452	Power System Operation and Control	3:0:0	3	7	Modern Energy Systems

25	ECE453	Foundations of Deep Learning	3:0:0	3	7	Miscellaneous
26	ECE454	Optical Fiber Communication	3:0:1	4	7	Analog/RF and Communication Engineering
27	ECE455	Graph Signal Processing	3:0:1	4	7	Analog/RF and Communication Engineering
28	ECE456	High Voltage Engineering	3:0:0	3	7	Modern Energy Systems
29	ECE369	Information Theory	3:1:0	4	7	Analog/RF and Communication Engineering
30	ECE458	Radar Communications	3:0:0	3	7	Analog/RF and Communication Engineering
31	ECE459	Computational Electromagnetics	3:0:0	3	7	Analog/RF and Communication Engineering
32	ECE460	Power System Protection and Switchgear	3:0:0	3	8	Modern Energy Systems
33	ECE461	HVDC Transmission	3:0:0	3	8	Modern Energy Systems
34	ECE462	WBG Devices for Power Circuits	3:0:0	3	8	1. Sensors and Nano-electronics 2. Modern Energy Systems
35	ECE463	Satellite Communications	3:0:0	3	8	Analog/RF and Communication Engineering
36	ECE464	Advance Electromagnetics Engineering	3:0:0	3	8	Analog/RF and Communication Engineering

Semester-wise course break-up

First Semester				
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**
1	CCC704	CCC704 (Environmental Studies)		4
2	MAT103	Mathematical Methods I	3-1-0	4
3	PHY101	Introduction to Physics I	3-1-0	4
4	ECE101	Basics of Electrical and Electronic Circuits	3-1-1	5
5	CSD101	Introduction to Computing and Programming	3-0-1	4
		Semester Credits		**21**

Second Semester				
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**
1		CCC		3
2	MAT104	Mathematical Methods II	3-1-0	4
3	PHY102	Introduction to Physics II	3-1-1	5
4	ECE103	Digital Electronics	3-1-1	5
5	ECE102	Semiconductor Devices	3-0-0	3
	ECE101	Basics of Electrical and Electronic Circuits (non-ECE)	3-1-1	5
		Semester Credits		**20**

Third Semester				
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**
1		CCC		3
2	MAT205	Mathematical Methods III - Probability and Statistics	3-0-0	3
3	ECE201	Electric Machines & Power Systems	3-0-1	4
4	CSD102	Data Structures	3-0-1	4
5	ECE202	Embedded Systems Hardware	3-0-1	4
6	ECE203	Signals and Systems	3-1-0	4
	ECE103	Digital Electronics (non-ECE)	3-1-1	5
		Semester Credits		**22**

Fourth Semester				
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**
1		CCC		3
2	DES211	UWE (Creativity & Concept in Design)		3
3	ECE205	Electromagnetic Engineering	3-1-0	4
4	ECE204	Analog Circuits	3-0-1	4
5	ECE206	Power Electronics and Machine Drives	3-0-1	4
6	ECE207	Principles of Communication Engineering	3-0-1	4
		Semester Credits		**22**

Fifth Semester				
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**
1		UWE		3
		CCC		3
2	ECE301	Control Systems	3-0-1	4
3	ECE302	Digital Signal Processing	3-0-1	4
4	ECE303	Computer Organization and Design	3-0-0	3
5		Major Elective - 1		3
6		Major Elective - 2		3
		Semester Credits		**23**

	Major Elective Courses
ECE351	VLSI Design
ECE352	Photovoltaic Power Generation
ECE353	Microwave Engineering
ECE354	Sensor, Measurement, and Actuators
ECE355	Scientific Computing using MATLAB
ECE356	RF and Microwave Circuit Design
ECE357	Introduction to Robotics
ECE363	Computer Communication Networks
ECE457	Information Theory and Coding
ECE370	Wireless Communications

Sixth Semester				
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**
1		CCC		3
2		UWE		3
3		UWE		3
4	ECE304	Artificial Intelligence and Machine Learning	3-0-0	3
5		Major Elective - 3		3
6		Major Elective - 4		4
7		Major Elective - 5		3
		Semester Credits		**22**

		Major Elective Courses
	ECE360	IoT - Architecture, Communication Technology, and Applications
	ECE361	Power System Analysis
	ECE362	Digital Communication
	ECE365	Object Oriented Programming
	ECE366	Antenna Theory and Wave Propagation
	ECE367	Digital Design with FPGAs
	ECE368	Special Topics in Microwave Engineering
	ECE371	Detection and Estimation
	ECE372	Modern Control Systems
	ECE373	Wireless Network Security
	ECE374	Reconfigurable Computing
	ECE375	Quantum Computing

Seventh Semester				
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**
1		CCC		3
2		Major Elective - 6		3
3		Major Elective - 7		3
4		Major Elective - 8		4
5		UWE		3
6		UWE		3
7	ECE498	Minor Project	0-0-3	3
		Semester Credits		**22**

	Major Elective Courses
ECE451	Design of CMOS Analog Circuits
ECE452	Power System Operation and Control
ECE453	Foundations of Deep Learning
ECE454	Optical Fiber Communication
ECE455	Graph Signal Processing
ECE456	High Voltage Engineering
ECE369	Information Theory
ECE458	Radar Communications
ECE459	Computational Electromagnetics

		Eighth Semester		
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**
1		CCC/UWE (Online Course/Offline Course)		3
2		Major Elective (Online Course/Offline Course) -9		3
3	ECE499	Major Project	0-0-6	6
		Semester Credits		**12**

	Major Elective Courses
ECE460	Power System Protection and Switchgear
ECE461	HVDC Transmission
ECE462	WBG Devices for Power Circuits
ECE463	Satellite Communications
ECE464	Advance Electromagnetics Engineering

Specialization

Requirement for Specialization Tracks: Student must earn a minimum of 16 Credits from a particular specialization (out of required 16 credits, 3 credits may optionally be earned from electives under "Miscellaneous" category). A student may choose to graduate without any particular specialization.

The department of Electrical Engineering offers the following four specialization tracks in the ECE program:

- **Modern Energy Systems**
- **Analog/RF and Communication Engineering**
- **Embedded Systems and Computer Engineering**
- **Sensors and Nano-electronics**

Students may earn their specialization and get their B. Tech degree in Electrical and Computer Engineering with specialization in "any of the four areas mentioned above".

List of courses to earn specialization

S. No.	Course Code	Basket of courses for specialization in 'Modern Energy Systems'	L:T:P	Credits	Semester Offered
1	ECE352	Photovoltaic/Renewable	3:0:0	3	5
2	ECE354	Sensor, Measurement, and Actuators	3:0:1	4	5
3	ECE361	Power System Analysis	3:0:1	4	6
4	ECE452	Power System Operation and Control	3:0:0	3	7
5	ECE456	High Voltage Engineering	3:0:0	3	7
6	ECE460	Power System Protection and Switchgear	3:0:0	3	8
7	ECE461	HVDC Transmission	3:0:0	3	8
8	ECE462	WBG Devices for Power Circuits	3:0:0	3	8
9	ECE372	Modern Control Systems	3-1-0	4	6

S. No.	Course Code	Basket of courses for specialization in 'Analog/RF and Communication Engineering'	L:T:P	Credits	Semester Offered
1	ECE453	Microwave Engineering	3:0:0	3	5
2	ECE356	RF and Microwave Circuit Design	3:0:1	4	5
3	ECE362	Digital Communication	3:1:1	5	6
4	ECE363	Computer Communication Networks	3:0:1	4	5
5	ECE370	Wireless Communications	3:0:0	3	5
6	ECE366	Antenna Theory and Wave Propagation	3:0:1	4	6
7	ECE368	Special Topics in Microwave Engineering	3:0:0	3	6
8	ECE454	Optical Fiber Communication	3:0:1	4	7
9	ECE455	Graph Signal Processing	3:0:1	4	7
10	ECE457	Information Theory and Coding	3:0:0	3	5
11	ECE458	Radar Communications	3:0:0	3	7
12	ECE459	Computational Electromagnetics	3:0:0	3	7
13	ECE463	Satellite Communications	3:0:0	3	8
14	ECE464	Advance Electromagnetics Engineering	3:0:0	3	8
15	ECE371	Detection and Estimation	3-0-0	3	6
16	ECE372	Modern Control Systems	3-1-0	4	6
17	ECE373	Wireless Network Security	3-0-0	3	6

18	ECE375	Quantum Computing	3-1-0	4	6
19	ECE369	Information Theory	3-1-0	4	7

S. No.	Course Code	Basket of courses for specialization in 'Embedded Systems and Computer Engineering'	L:T:P	Credits	Semester Offered
1	ECE357	Introduction to Robotics	3:0:1	4	5
2	ECE354	Sensor, Measurement, and Actuators	3:0:1	4	5
3	ECE360	IoT - Architecture, Communication Technology, and Applications	2:0:1	3	6
4	ECE363	Computer Communication Networks	3:0:1	4	6
5	ECE367	Digital Design with FPGAs	3:0:1	4	6
6	ECE375	Quantum Computing	3-1-0	4	6

S. No.	Course Code	Basket of courses for specialization in 'Sensors and Nano-electronics'	L:T:P	Credits	Semester Offered
1	ECE351	VLSI Design	3:0:1	4	5
2	ECE354	Sensor, Measurement, and Actuators	3:0:1	4	5
3	ECE367	Digital Design with FPGAs	3:0:1	4	6
4	ECE451	Design of Analog CMOS Circuits	3:0:0	3	7
5	ECE462	WBG Devices for Power Circuits	3:0:0	3	8
6	ECE374	Reconfigurable Computing	3-0-0	3	6

Syllabus of offered courses

ECE101: Basics of Electrical & Electronic Circuits		
Unit	**Course Unit description**	**Number of Lecture hours**
Unit I:	*Basic Components of Electrical Circuits (4-5):* Fundamental electrical variables – charge, current, voltage & power; Independent Voltage & Current sources; Ideal circuit elements - Resistor, Capacitor & Inductor; Controlled Source models – VCVS, VCCS, CCVS & CCCS - definitions & circuit models; Concepts of Linearity, Time-invariance & Passivity.	4-5
Unit II:	*Linear D-C Circuits:* Kirchhoff's laws, Series & Parallel combinations of resistances, Voltage & Current divisions, Analysis of resistive circuits using Loop & Node equations – with independent sources, and with both independent and controlled sources.	5-6
Unit III:	*Time-domain Analysis of LTI Circuits:* Natural & forced responses of basic RC & RL circuits, Natural & forced responses of Series & Parallel RLC circuits.	4-5
Unit IV:	*Sinusoidal Steady State Analysis of A-C Circuits:* Notions of phasors, impedance, admittance & transfer function; Frequency response vs transient response; Responses of RC, RL & RLC circuits – series & parallel Resonance; Simple passive Filters & their Bode plots; Loop & Node Analysis of a-c circuits with independent & controlled sources.	6-7
Unit V:	*Useful Circuit Analysis Techniques:* Superposition, Source transformations, Thevenin's equivalent, Norton's equivalent, Maximum Power transfer, Delta-wye conversions,	6-7
Unit VI:	*Basic Amplifiers:* Amplifier parameters & controlled source models; VCVS model of an Op-amp; Amplifiers using ideal OPAMP; Frequency response of basic OPAMP-based amplifiers.	6-7

Unit VII:	Waveform Generators: Condition of harmonic oscillation; RC and LC oscillator circuits; Square wave generator using 555 Timer and Digital inverters (TTL/CMOS). *Additional Topics (if time permits may be included with Lab. Experiments)* *D-C Power Supply: Half-wave and Full-wave Rectifiers, Shunt Capacitor filter, Voltage Regulator, Regulated D-C Power Supply.* *Wave Shaping Circuits: Diode Clippers; Precision Clippers using Diode and Op-amp; Diode Clamp; Peak Detector and Peak Hold circuits; Sample and Hold circuit.*	5-6
	Recommended Text book(s)	
	1. *Engineering Circuit Analysis – Hayt, Kemmerly & Durbin, Tata McGraw Hill,* 2. *Electronic Devices and Circuit Theory by Robert L. Boylestad, Pearson Publication.*	
	Reference Text Books	
	1. *Circuit theory and analysis by Robert L. Boylestad, Pearson publication.* 2. *The Art of Electronics – Horowitz & Hill, Cambridge University Press.*	

ECE102: SEMICONDUCTOR DEVICES		
UNIT	**COURSE UNIT DESCRIPTION**	**NUMBER OF LECTURE HOURS**
UNIT I:	***Basic Semiconductor Properties and band theory***: Crystal Structure and Systems, Miller Indices and notation for directions and planes, Concept of holes, Energy bands, E-k diagrams, Band-structure, *Conductivity* effective mass	3
UNIT II:	***Equilibrium Carrier Statistics:*** Density of states (DoS), Fermi function, Equilibrium electron and hole concentrations	2
UNIT III:	***Recombination-Generation Processes:*** Recombination-generation statistics, Low-level injection	2
UNIT IV:	***Carrier Transport:*** Drift current, Diffusion current, Continuity Equations, Quasi-Fermi levels	3
UNIT V:	**Application of above-developed theory to devices**: - P-N junctions: **6 hours** - Metal Semiconductor devices: **1 hour** - MOS capacitors (MOSCAP): **3 hours** - Bipolar Junction Transistors (BJTs): **6 hours** - MOSFETs: **8 hours** - Power semiconductor devices like SCRs, Thyristors & Triacs, IGBTs and Power MOSFETs: **4 hours**	28
UNIT VI:	***Integrated Circuits:*** Brief introduction to how above semiconductor devices are fabricated in an integrated circuit (IC)	1
	RECOMMENDED TEXT BOOK(S)	
	1. *Solid State Electronic Devices*, Ben G. Streetman and Sanjay Banerjee; Pearson Prentice Hall Publishers	
	REFERENCE TEXT BOOKS	
	1. *Advanced Semiconductor Fundamentals, Volume VI of the Purdue Modular Series on Solid State Devices*, Robert F. Pierret; Pearson Prentice Hall Publishers **2.** *Physics of Semiconductor Devices*, S. M. Sze; John Wiley & Sons	

ECE103: DIGITAL ELECTRONICS		
UNIT	**COURSE UNIT DESCRIPTION**	**NUMBER OF LECTURE HOURS**
UNIT I:	**Digital Processing of Information-** Analog and Digital representations of information; Information processing steps – logic and arithmetic; Range of digital circuits and systems.	**3**
UNIT II:	**Number Systems and Arithmetic** - Positional number systems – Binary, Decimal, Octal, Hexadecimal; Signed number representations; Arithmetic operations.	**6**
UNIT III:	**Digital Logic** – Binary variables; Basic logic operations – AND, OR, NOT; Basic gates; Essentials of Boolean algebra; De Morgan's laws; Truth Table; Boolean functions; Transforming a logical problem statement into a Boolean expression.	**3**
UNIT IV:	**Combinational Circuit Design** – Realisation of Boolean functions using gates; Karnaugh map; Minimisation of Boolean functions; Multiplexer-based realization of K-maps; Combinational circuit design using multiplexers and gates.	**7**
UNIT V:	**Sequential Circuit Design** – Latches and Flip-flops; Ripple counters; Sequence generator using flip-flops; State Table and State Diagram; Synchronous counters; Shift Registers; Ring and MLS counter, Introduction to Memories.	**11**
UNIT VI:	**Hardware Description Language** – VLSI digital design flow; Need for HDL; Language reference manuals for Verilog – syntax and semantics; Verification and synthesis of Verilog designs.	**9**
UNIT VII:	**Processor Architecture** - Processor as a programmable digital system; Basic constituents of a processor – Programmable ALU, Register array and Program sequencer; A simple single-bus architecture and its Instruction Set.	**6**
	RECOMMENDED TEXT BOOK(S)	
	1. M. Morris Mano and Ciletti M.D., "Digital Design", 4th Edition, Prentice-Hall 2006. **2.** T.L. Floyd, "Digital Fundamentals", 10th Edition, Pearson education, 2011.	
	REFERENCE TEXT BOOKS	
	i) R. P. Jain, "Modern Digital Electronics", 3rd Edition, Tata McGraw Hill, 2003. ii) M. Morris Mano, "Digital Logic and Computer Design", PHI, 2005. iii) Taub and Schilling, "Digital Integrated Electronics", McGraw Hill, International Edition. IV) A. P. Malvino and D.P. Leach, "Digital Principles and Applications", 6th Edition, Tata McGraw-Hill, 2008	

ECE201: ELECTRIC MACHINES AND POWER SYSTEMS
Transformers: Different types of transformers, Transformer Construction, Core and Shell type of transformers, Core materials and laminated core, Cooling systems, Equivalent circuit of a transformer, OC test, SC test, Voltage regulation and efficiency, Testing of transformers, Polarity test, three-phase transformer connections, Auto-transformer, Applications. **DC Machines:** Construction and working principle of DC motors and generators, commutation process, armature reaction, types of dc motors and their operating characteristics, starters, speed control of dc motors, losses and efficiency of dc motors, applications. **Three-phase Induction motors:** Construction, rotating magnetic field, principle of operation of three-phase Induction motors, equivalent circuit diagram, Torque-slip characteristics, no-load and blocked rotor tests, starting of induction motor, speed control of induction motors, losses and efficiency, applications.

Single-phase Induction motors: Construction, Main and starting windings, starting methods, split phase starting, capacitor split phase starting, torque-slip characteristics, applications.

Three-phase Synchronous machines and electric power generation: Construction**,** Types of synchronous machines, Concepts of three-phase circuits, open-circuit and short-circuit characteristics, synchronous reactance, voltage regulation of the alternators, active and reactive power flow, synchronization process, two reaction theory of salient pole type synchronous machines, power-angle characteristics, damper winding, types of power plants.

Modeling and analysis of transmission lines: Types of overhead lines, poles and towers, Transmission line voltage levels in our country, conductors, resistance, inductance and capacitance of transmission lines (without derivation), Short, Medium, and long transmission lines, T-and pi-models of medium and long transmission lines, Voltage regulation, efficiency, active and reactive power flow through a transmission line, Equations of long transmission line (without derivation), Ferranti effect, Surge impedance loading. Corona phenomenon.

Overhead Line Insulators: Types of insulators, Potential distribution over a string of suspension insulators, String efficiency, Methods of equalising the potential, grading rings, arcing horns.

Distribution System: Primary distribution and secondary distribution, overhead and underground distribution, radial, ring main, interconnected distributions systems, voltage drop calculations, tap changing transformers.

- **Text Books:**
  1. D. P. Kothari and I. J. Nagrath, *Electrical Machines*. McGraw- Hill Higher Education, 4th edition, 2010.
  2. S. J. Chapman, Electric Machinery Fundamentals. McGraw-Hill, Inc. 5th edition, 2012.
  3. P. S. Bhimbra, *Electrical Machinery*. Khanna publishers, 2012.
  4. C. L. Wadhwa, *Electrical Power Systems*. New Age Publication, 6th edition, 2014.
- **Reference Books:**
  1. Fitzgerald and Kingsley, *Electrical Machinery*. McGraw- Hill Higher Education, 7th edition, 2013.
  2. M. G. Say, *The Performance and Design of Alternating Current Machines*. CBS Publishers, 3rd Edition,
  3. T. Gonen, *Electric Power Transmission System Engineering: Analysis and Design*. CRC Press, Taylor and Francis Group, New York, 2009.
  4. W. D. Stevenson Jr. and J. J. Grainger, *Power System Analysis*. McGraw Hill, 2017.

ECE202: EMBEDDED SYSTEMS HARDWARE		
UNIT	**COURSE UNIT DESCRIPTION**	**NUMBER OF LECTURE HOURS**
UNIT I:	**Embedded system basics and microprocessors:** **Introduction to the embedded system**: i) components of embedded system, ii) characteristics of embedded system, iii) challenges in embedded system design, and iv) architecture of a general embedded systems **Microprocessor:** i) introduction, ii) generations of microprocessors, iii) classification of the microprocessor, iv) introduction to 8085 microprocessors, v) pinout and signals of 8085, vi) functional block diagram of 8085, vii) addressing modes and interrupts in 8085, and viii) instruction sets and programming in 8085.	**6**
UNIT II:	**8-bit microcontrollers:** **8051 microcontroller:** i) features and introduction of 8051, ii) block diagram and pinouts, iii) programming model, iv) Internal RAM	**10**

	organization, v) interrupts, vi) C programming of 8051, and vii) interfacing some important peripherals to 8051. **Arduino:** i) introduction to Arduino (development board and IDE), ii) programming to Arduino, and iii) interfacing some important peripherals to Arduino.	
UNIT III:	**32-bit microcontrollers:** i) overview, ii) functional block diagram, iii) Integrated Development Environment, iv) General purpose input-output (GPIO), v) Analog interface, vi) Timers, vii) Hardware Abstraction Layer (HAL).	**8**
UNIT IV:	**Communication Protocol:** i) overview of Serial Peripheral Interface Protocol (SPI protocol), ii) overview of Inter –IC (I2C) communication protocol, iii) overview of Universal Asynchronous Receiver/Transmitter (UART) protocol, iv) overview of USB communication technology, and v) overview of RFID communication technology.	**8**
UNIT V:	**Hands on experience on simple embedded systems:** i) ADC and DAC, ii) PID control, iii) sensors and actuators, iv) position and movement control, v) data communication interfaces, and vi) Internet of Things.	**8**
	RECOMMENDED TEXT BOOK(S)	
	1. Ramesh S. Gaonkar, "*Microprocessor - Architecture, Programming and Applications with the 8085*", 5th edition, Penram International Publishing Private Limited. **2.** Ayala, Kenneth J. "*The 8051 Microcontroller Architecture Programming and Applications",* West Publishing Company. **3.** Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay, "*The 8051 Microcontroller and Embedded Systems Using Assembly and C",* 2nd edition. **4.** Simon Monk, "*Programming Arduino Getting Started with Sketches*", McGraw-Hill Education. **5.** Donald Norris, "*Programming with STM32 Getting Started with the Nucleo Board and C/C++*", McGraw-Hill Education.	
	REFERENCE TEXT BOOKS	
	1. KCS Murti, "*Design Principles for Embedded Systems*", Springer Verlag, Singapore, First Edition.	

ECE203: Signals and Systems

1. Classification and representation of signals and systems, Continuous time & Discrete time signals and systems, Impulse and Step response of a system, linear systems, linearity, time invariance, causality, signal properties -LTI systems, Convolution
2. Fourier series, Fourier transform and properties, relation between Fourier transform and Fourier series, Sampling and reconstruction, Group delay, Phase delay, DFT.
3. Laplace transforms- representation of signals using continuous time complex exponentials, relation of Laplace and Fourier transform, concept of ROC and transfer function- block diagram representation, Inverse Laplace transform, properties, analysis and characterization of LTI systems using Laplace transforms.
4. Z transforms- representation of signals using discrete time complex exponentials-properties, inverse Z transforms, ROC, Analysis and characterization of LTI systems using Z transforms, block diagram, transfer functions
5. Introduction to random variable and random process, State space analysis, Introduction to Two port networks and parameters.

RECOMMENDED TEXT BOOK(S)

1. A.V. Oppenheim, A.S. Willsky & S.H. Nawab, "Signals & Systems", 2nd edition, PHI, 1997.
2. Lathi, B. P., "Principles of Linear Systems and Signals", 2nd Ed., Oxford University Press.
3. S. Haykin & B. Van Veen, "Signals and Systems", 2nd edition, John Wiley & sons, 2004.
4. Ziemer and Tranter, "Signals and Systems, 4th edition, Pearson LPE.

ECE204: Analog Circuits

1. **Review of BJT and MOSFET:** Review of physical properties and basic I-V equations of BJT and MOSFET; various biasing operating modes of BJT and MOSFET, Low-frequency incremental equivalent circuits
2. **Two-Port Networks and their parameters:** Hybrid Parameters of BJT.
3. **Transistor biasing schemes:** Resistive Biasing and Current Mirror Biasing
4. **Small-signal Analysis of Amplifiers:** Single-stage amplifiers-CE, CB and CC and their MOSFET counterparts.
5. **Multi-transistor Amplifiers:** Darlington pair, Difference amplifier, and Active load and Cascade amplifier.
6. **Frequency Response:** High-frequency model and Frequency Response of different types of amplifiers.
7. **Basic Operational Amplifier Design:** Frequency Response of Op-Amp, gain margin, phase margin, compensation of gain margin and phase margin, Negative feedback and its impact on amplifier performance - gain and bandwidth, design of two-stage Op-amp.
8. **A few applications of Op-Amps** e.g. oscillators, filters.

RECOMMENDED BOOK(S)

- **Text Books**

1. Microelectronic Circuits: Theory And Applications: Fifth Edition, by Sedra, Adel S.; Smith, Kenneth C., Oxford University Press, 2007
2. Electronic Devices and Circuits, Sixth Edition by Theodore F Bogart, Pearson, 2011.

- **Reference Books**

1. Microelectronics: Circuit Analysis and Design (ISE), 4th Edition by Donald A. Neamen, Mc-Graw Hill 2021.
2. Electronic Devices and Circuit Theory: 9th Edition by Robert Boylestad, Pearson, 2007.
3. Operational Amplifiers with Linear Integrated Circuits, 4th Edition, by William D. Stanley, Pearson, 2004.

ECE205: Electromagnetic Engineering

1. Review of vector algebra and calculus, coordinate transformations, Scalar and Vector fields, Vector calculus, Divergence, the Divergence Theorem, Curl and Stokes theorem.
2. **Electrostatics:** Coulomb's Law and concept of Electric Field, Electric field due to charge distribution, Gauss's law, Electric potential, Electric field in materials, Conductors and Dielectrics, Material polarization, Boundary conditions, Resistance and capacitance, Method of Images, Poisson's and Laplace's equations.
3. **Magnetostatics**: Bio-Savart law, Ampere's Law and its applications, Maxwell's equation for static EM fields, Magnetic materials, Boundary conditions, Inductor and inductance, magnetization, magnetic energy.
4. **Maxwell's Equations:** Faraday's law, Inconsistency of Amperes law, Continuity equation, Displacement current, Maxwell's equations, Boundary conditions, different forms of Maxwell's equations.
5. **Transmission Line:** Transmission line parameters and equations, characteristic impedance, open and short circuited lines, standing wave and reflection losses. Impedance matching, Smith Chart, Simple and double stub matching.
6. **EM Wave Propagation**: Wave propagation in free space, Conductors and dielectrics, Polarization, Phasor notation, Phase velocity, Group velocity; Reflection at the surface of the conductive medium, Surface Impedance, Depth of penetration, Poynting theorem, Poynting Vectors and power loss in a plane conductor.

7. **Antenna and Radiation:** Scalar and vector potentials. Radiation from a current filament, half-wave dipole and small loop antennas. Antenna characteristics, radiation pattern, radiation intensity, directivity and power gain., Effective area and Friis equation.
8. **Electromagnetic Interference and Electromagnetic Compatibility:** Introduction to Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC).
9. **Bio-Electromagnetics**: Retinal optic fibers, Heart dipole field, Biological fields.

RECOMMENDED BOOK(S)

1. Engineering Electromagnetics - William H. Hayt, Jr.
2. Elements of Electromagnetics- M. N. O. Sadiku, Oxford University Press.
3. Field and wave electromagnetics - D. K. Cheng, pearson.
4. Electromagnetic Waves & Radiation Systems, Jordon E C Balmain.
5. Electromagnetic Field Theory & Transmission Lines, G S N Raju, Pearson
6. Electromagnetics with Applications, Kraus & Fleisch, TMH.

ECE206: Power Electronics and Machine Drives

1. Introduction to power electronic circuits, Examples of power electronic converters and range of controlled power.
2. Active mode versus switched mode operation, losses in switches, cooling requirements, heatsink specifications
3. Brief description of construction and working of power diodes, thyristors, power MOSFET and IGBT, their switching characteristics.
4. Different methods of triggering a thyristor, gate drive circuits for IGBT and MOSFET. Static and dynamic switching characteristics of power diode and thyristor, requirement of snubber circuits.
5. AC to DC conversion (uncontrolled type): Uncontrolled rectifier using diodes for both single-phase and three-phase ac input, discussion on output filter and ac source current.
6. AC to DC controlled conversion using thyristors for both single-phase and three-phase ac supply. Half controlled and fully controlled rectifiers for resistive and inductive loads, Waveforms of supply and load side currents and voltages, expression for output voltage, Concept of distortion and displacement power factor, harmonic distortion factors /THD etc.
7. DC to DC conversion: Concept of buck and boost converter assuming ideal switches and diodes. Practical buck and boost converter using thyristors, MOSFETs and IGBTs. Advantage of higher frequency switching, switching losses, limitations due to switching speed, stray inductance etc.
8. Switched Mode Power Supply Circuits: fly-back and forward types, considerations on high frequency transformer design, practical SMPS circuits.
9. DC to AC conversion (Inversion): Inverters for DC to single phase AC conversion, DC to three phase AC conversion, PWM Inverter, PWM techniques, Sine wave PWM (SPWM) and selective harmonic elimination type PWM techniques.
10. AC to AC conversion: phase angle control using TRIACs
11. Introduction to Electric Drives: What is Electric Drive? Different components of Electric Drive, Different types of Electric Drives.
12. Dynamics of Electric Drives: Fundamentals of speed-torque relations, multi-quadrant operation in speed-torque plane, Nature and classification of load torques, Calculation of time and energy spent in transient operations, steady state stability of drives.
13. DC Motor Drives: Overview of different types of dc motors and their torque-speed characteristics, starting and braking methods of dc motors, conventional speed control methods, modern speed control methods using power electronic converters, time and energy loss calculations during starting and braking of separately excited dc motor.
14. Induction Motor Drives: Overview of 3-phase Induction motor torque-speed characteristics, squirrel-cage and slip-ring induction motor, different types of starting and braking of induction motor, time and energy loss calculations in transient operation of induction motor, Speed

control of 3-phase induction motor using conventional methods and using power electronic converters, V/f control and slip power recovery based control of induction motor speed and torque, torque-speed characteristics and speed control of single phase induction motor.

15. Brushless DC motor, Switched Reluctance Motor & Stepper Motor Drives: Brief mention of Construction, operation and control of these drives.

RECOMMENDED BOOK(S)

1. Power Electronics: Circuits, Devices and Applications, by M. H. Rashid, Pearson publishers, India.
2. Power Electronics: Converters, Applications and Design by Ned Mohan, Tore M. Undeland, and William P. Robbins, John Wiley & Sons.
3. Fundamentals of Electrical Drives by G .K .Dubey, CRC Press.

ECE207: Principles of Communication Engineering

1. Review of Signals & Systems: Fourier series, Fourier transform and its properties, Hilbert transform, complex-baseband representation.
2. Analog Amplitude & Angle Modulation Schemes: amplitude modulation techniques: double-sideband (DSB) modulation, full amplitude modulation (Full AM) and its variants (SSB/VSB), Frequency translation and mixing. Phase and Frequency modulation, Demodulation of FM, Frequency division multiplexing (FDM).
3. Review of Probability Theory: Random variable and Random processes, probability distribution, statistical averages, some useful distributions, auto-correlation (in continuous and discrete-time), White Gaussian noise process: auto-correlation function and power spectral density, LTI filtering.
4. Performance of Analog Communication Schemes in the presence of noise: The effect of additive white Gaussian noise in the reception of amplitude and angle-modulated signals.
5. Baseband Data communication: Line codes and their power spectra, Effects of filtering of digital data – ISI, Pulse shaping- Nyquist's criterion for zero ISI, Baseband digital data transmission in white Gaussian noise: Matched filter and correlation.
6. Introduction to Digital Communication: A basic form of a digital communication system, Geometrical representation of signals, Gram Schmidt orthogonalization procedure, Signal Space Representation of M-ary Signal Sets, Conversion of the continuous AWGN channel into a vector channel, Likelihood functions, Coherent detection of signals in noise - MAP & ML detection, Correlation receiver, Equivalence of correlation and matched filter receivers, Probability of error, bit versus Symbol error probabilities.
7. Passband Digital Data communication: Hierarchy of digital modulation techniques and their constellations: BPSK, QPSK, M-ary QAM, M-ary PSK, Minimum Shift Keying (MSK), Frequency Shift Keying (FSK). Coherent detection of signals: Probability of error and performance comparison. Non-coherent reception and their performance.
8. Introduction to carrier and symbol timing synchronization: Importance in signal demodulation, carrier frequency and phase estimation– decision directed and power of N methods, symbol timing estimation.
9. Multiple access schemes: TDMA, FDMA, CDMA.

RECOMMENDED BOOK(S)

1 Simon Haykin, "Communication Systems", 4th Edition, John Wiley & Sons, 2001.
2 Rodger E. Ziemer and William H. Tranter, "Principles of Communication-Systems, Modulation and Noise", 7th Edition, John Wiley & Sons, 2015.
3 S. Haykin and M. Moher, Introduction to Analog & Digital Communications, 2nd Edition, John Wiley & Sons, Inc., 2007.

ECE301: Control Systems

1. **Introduction and Mathematical Modeling of Physical Systems:** Classification of control systems: Open-loop and Closed-loop systems, Effect of feedback, Mathematical modeling of physical systems, Transfer Function, Block diagrams of control systems, Block diagram manipulations.
2. **Time-Domain Analysis:** Standard test signals for the time response of control systems, Time-response of 1st order and 2nd order systems, Transient and steady-state responses, Steady-state errors, Static error constants, Type-0, Type-1, and Type-2 systems, Effects of adding poles and zeros to transfer functions, Dominant poles.
3. **Stability of Linear Control Systems:** Bounded-Input Bounded-Output (BIBO) stability, Absolute and relative Stability, Routh-Hurwitz stability criterion.
   Root Locus Technique: Defining root locus, properties and sketching of root locus for negative and positive feedback systems, Design via root locus; Improving steady-state and transient response using cascade compensation, PI, PD, and PID controllers, Lag, lead, and lag-lead compensators.
4. **Frequency-Domain Analysis:** Correlation between time-domain and frequency-domain analysis, Polar plot and Bode plots, Introduction to Nyquist stability criterion, Nyquist plot, Gain margin and phase margin, Constant M and N circles; Nichols Chart, Design of feedback control systems using frequency response techniques.
5. **State-Variable Analysis:** Concept of state-space representation, converting a transfer function to state-space, converting state-space to transfer function, state-transition matrix and its properties, linearization, Laplace transform and time-domain solution of state equations, observability and controllability of linear Systems.
6. Introduction to digital control systems.

RECOMMENDED BOOK(S)

- **Textbooks:**

  1. M. Gopal, *Control Systems: Principles and Design*. McGraw-Hill, 4th edition, 2012.
  2. N. Nise, *Control Systems Engineering*. Wiley India, 7th edition, 2011.

- **Reference Books:**

  1. B. C. Kuo and F. Golnaraghi, *Automatic Control Systems*. Wiley India, 4th edition, 2009.
  2. K. Ogata, *Modern Control Engineering*. Prentice Hall India Learning Private Limited, 5th edition, 2015.

ECE302: Digital Signal Processing

1. **Discrete time signals and systems**: Sequences; representation of signals on orthogonal basis; Sampling and reconstruction of signals; State Space representations.
2. **Discrete systems**: attributes, Z-Transform, Analysis of LSI systems, Frequency analysis, Inverse Systems, Discrete Fourier Transform (DFT), Fast Fourier Transform algorithm, Implementation of Discrete Time Systems.
3. **Design of FIR Digital filters**: Window method, Eigen based methods, Park-McClellan's method.
4. **Design of IIR Digital Filters**: All pass based design, Butterworth, Chebyshev and Elliptic Approximations; Low pass, Band pass, Band stop and High pass filters, Matched filters, CIC filter design. Effect of finite register length in FIR filter design.
5. Parametric and non-parametric spectral estimation. Introduction to Multirate signal processing. Application of DSP to Speech and Radar signal processing

RECOMMENDED BOOK(S)

1 A. V. Oppenheim and R. W. Schafer, Digital Signal Processing. Pearson 2015.
2 J. G. Proakis and D. G. Manolakis, Digital Signal Processing. Pearson 2009.

ECE303: Computer Organization and Design
1. **Internal operation of computers**: Layers of a computer system, operating systems, compiler/assembler/linker/loader, number systems/representations, binary arithmetic, memory types/management, limits imposed by VLSI manufacturing process such as limitations of Moore's Law, power and yield/cost 2. **RISC-V Instruction Set Architecture**: Assembly language, execution, function calls, branches 3. **Datapath design with single-cycle non-pipelined control:** Adding support for instructions one by one 4. **Pipelined Datapath and control:** Performance and energy "Iron Laws" of CPU design, pipelined datapath and control, hazards 5. **Memory hierarchy and caches:** Memory hierarchies, cache hits, misses, write policies, replacement policies, multi-processor caches and coherency, virtual memory 6. **Interrupts and pipelined datapaths** 7. **Parallelism:** Amdahl's Law, data-level parallelism, vector instructions, loop-unrolling, thread-level parallelism, hardware threads versus software threads 8. **Miscellaneous:** Benchmarks, design process, architecture simulators for functionality and performance
RECOMMENDED BOOK(S)
1 **Computer Organization and Design RISC-V Edition: The Hardware Software Interface**, D. A. Patterson and J. L. Hennessy; Morgan Kaufmann Publishers.

ECE304: Artificial Intelligence and Machine Learning
1. **Types of Learning:** Supervised, Unsupervised and Reinforcement; Regression and Classification Problems. 2. **Concepts:** Bias and Variance, Generalization, Overfitting, Training and Test Datasets, Cross-validation, Accuracy Measures for Regression and Classification, Imbalanced Datasets. 3. **Statistical Learning:** Naïve Bayes Classifier, k-NN Classifier, Linear Regression, Logistic Regression, Softmax function. 4. **Support Vector Machines:** Optimum Margin Classifier, Constrained Optimization, Lagrange Multipliers, Primal/Dual Problems, KKT Conditions, Kernels, Quadratic Programming. 5. **Neural Networks:** Multilayer Perceptron Networks, Backpropagation, Nonlinear Regression, Multiclass Discrimination, Training Procedures 6. **Decision Trees:** Concepts, C4.5 and CART Decision Trees 7. **Unsupervised Learning:** K-means Clustering, Gaussian Mixture Models 8. **Dimensionality Reduction:** Feature Selection, Principal Component Analysis, Linear Discriminant Analysis.
RECOMMENDED BOOK(S)
1. M. Gopal, "Applied Machine Learning", 2nd Edition McGraw-Hill, 2022. 2. E. Alpaydin, "Introduction to Machine Learning", 3rd Edition, The MIT Press, 2014. 3. T. Hastie, R. Tibshirani and J. Friedman, "The Elements of Statistical Learning: Data Mining, Inference and Prediction", 2nd Edition, Springer, 2009.

ECE351: VLSI Design

1. Introduction to VLSI, MOSFET basics, short channel MOS issues, CMOS basic flow, Design of digital and combinational blocks, emerging device technologies trends as per ITRS.
2. **CAD and Computer Tools Used**: Cadence Virtuoso
3. **Models for Digital Design (5)**: Miller Capacitance, the Digital MOSFET Model, and Effective Switching Resistance of Long Channel MOSFET, Short-Channel MOSFET Effective Switching Resistance, Capacitive Effects.
4. **CMOS Technology (6)**: Static CMOS inverter, DC Characteristics, Noise Margins, Inverter Switching Point, Ideal Inverter VTC. Dynamic Characteristics of CMOS inverter: Computing the capacitance-propagation delay sizing inverter for performance optimization. Combinational MOS logic circuits (Parallel Connection of MOSFETs, Series Connection of MOSFETs, NAND Gate, Quick Estimate of Delays, Number of Inputs, and Complex CMOS Logic Gates.
5. **Other Design Styles (5)**: MOSFET Pass Gate, Delay through a Pass Gate, Transmission Gate, Sizing in Pass transistor. Applications of the Transmission Gate as Path Selector and Static Circuits. Differential Cascode Voltage Switch Logic, Pseudo NMOS, and other logic design styles
6. **Delay Analysis (6)**: Delay analysis using Elmore Delay, Delay analysis using Logical and electrical effort. Designing the circuits for large capacitive loads. Analysis of Super buffer. Delay calculation in datapath.
7. **Designing logic for reduced supply voltages (3):** Introduction, Overview of Power Consumption, and Low-Power Design through Voltage Scaling, Estimation and Optimization of Switching Activity, Reduction of Switched Capacitance.
8. **Dynamic CMOS design (4)**: Fundamentals of Dynamic Logic, Charge Leakage, Dynamic Circuits, Domino logic, Optimization of Domino logic, and NORA logic.
9. **Design of sequential Circuit (4):** Bistability Principle, Timing metric, Edge Triggered Register Design, TSPC Design
10. **Memory Design (6):** Array Subsystem, Design of NAND ROM, NOR ROM, Decoders Design for ROM, Introduction to NVM. Design of Programmable Logic: Pseudo NMOS PLA, 6T SRAM Design, Read, Write and Hold operations of 6T-SRAM, SRAM peripheral Design, Introduction to DRAMs.

RECOMMENDED BOOK(S)

- **Text Books**

1. Principles of CMOS VLSI Design. A Systems Perspective, 3rd Edition, by Neil H. E. Weste, Karman Eshraghian, Addison-Wesley, 2004
2. CMOS Digital Integrated Circuits: Analysis and Design, S.-M. Kang and Y. Leblebici, 2nd Edition, McGraw-Hill, Inc., 1999

- **Reference Books**

1. Circuit design layout and simulation, R. Jacob Baker,3rd Edition, Wiley Publication,2010
2. Digital Integrated Circuits: A Design Perspective, Jan M. Rabaey, Prentice Hall, Inc., 1996

ECE352: Photovoltaic Power Generation

1. Introduction of Solar Cell: Renewable energy sources, Current status of PV power generation in India, Advantages and challenges of solar energy, Solar cell technology, P-N junction diode, Introduction to P-N junction in equilibrium and non-equilibrium conditions, P-N junction under illumination: solar cell, Generation of a photo voltage, Photo generated current, Current-voltage (I-V) equation of solar cell, I-V characteristics of solar cell.
2. Design of PV Cell, Module and Array: Short circuit current, Open circuit voltage, Fill factor, Efficiency, modelling of a PV cell, Effect of series and shunt resistances on efficiency, Effect of solar radiation and temperature on efficiency, modelling of a PV module and array
3. Solar Radiation: Extra-terrestrial solar radiation, Solar spectrum at the Earth's surface, Declination angle, Apparent motion of the sun and solar altitude, Angle of sunrays on solar collector, Sun tracking, Estimation of solar radiation empirically
4. Identification of Solar PV Module: PV parameters estimation of a single diode model (SDM) and double diode model (DDM) PV module, Conversion of PV module parameters to array parameters, Temperature and solar irradiation dependence PV parameters, Study of I-V and power-voltage (P-V) characteristics of a PV array under different environmental conditions using Matlab simulation
5. Maximum Power Point Tracking (MPPT) Methods of a PV Source: Fractional short-circuit current (FSCI) technique, Fractional open circuit voltage (FOCV) technique, Hill Climbing/ Perturb & Observed (PO), Incremental conductance, One cycle control (OCC) technique, Differention technique, Feedback voltage and current technique, Load current/Load voltage maximization technique, Fuzzy logic based MPPT technique, Artificial neural network based MPPT technique, Particle swarm optimization based MPPT technique, Gauss-Newton, Steepest-Decent, Levenberg-Marquardt
6. Partial Shading of a PV Array: Shading effect of a PV array, Mismatch loss, Different types of PV configuration to reduce mismatch loss, Effect of bypass diode in a PV array under shading conditions, Extraction of maximum power from a PV array under partial shading conditions
7. Power Electronics Application in PV System: DC to DC converters, Control of DC to DC converter, Input side reflected impedance of DC to DC converters, DC to AC converter (Inverter), Grid integrated PV system: Single phase grid connection, Three phase grid connection.
8. PV System with Storage: Cells and batteries, Lead acid cell, Nickel cadmium storage cell, Nickel metal hydride (NiMH) Cells, Lithium cells, Stand-alone PV system, Design of PV water pumping system
9. Impact of DG integration on power quality and reliability: Power quality distrubances: Transients, Voltage sags and swells, Over-voltages and under-voltages, Outage, Harmonic distortion, Voltage notching, Flicker, Electrical noise, Impact of DG integration: Simple standby generation scheme, Secondary DG system with power quality support, Primary DG system with power quality support to priority loads, Soft grid-connected DG with power quality support to priority loads, DG with intermittent solar PV within power quality environment

RECOMMENDED BOOK(S)

- **Text Books:**
  1. Chetan Singh Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI learning publication, 2015.
  2. Remus Teodorescu, Pedro Rodriguez, Dezso Sera, Sergiu Spataru, Laszlo Mathe, Sergiu Spataru, "Grid Connected Photovoltaic Power Systems", John Wiley & Sons Inc, 2019
  3. S. Chowdhury, S.P. Chowdhury and P. Crossley, "Microgrids and Active Distribution Networks", IET, First Edition, 2009.
- **Reference Books**
  1. A. K. Mukerjee and Nivedita Thakur, "Photovoltaic Systems: Analysis and Design", PHI learning publication, 2011.
  2. Garg & Prakash and H. P. Garg, "Solar Energy Fundamentals and Applications", Tata McGraw-Hill Education, 2017.
  3. Ali Keyhani, "Design of Smart Power Grid Renewable Energy Systems", Wiley- IEEE Press, 2011.
  4. Mukund R. Patel, "Wind and Solar Power Systems: Design, Analysis, and Operation", Taylor & Francis, 2006.

ECE353: Microwave Engineering
Introduction of Microwaves and their applications. Waveguides: Rectangular Waveguides, Solution of Wave equation in TE and TM modes. Power transmission and Power losses. Excitation of modes in Rectangular waveguides, circular waveguides: Basic idea of TE and TM modes, field patterns, TEM mode of propagation. Waveguide Components: Scattering matrix representation of networks, Rectangular cavity and circular cavity resonators. Waveguide Tees, Magic Tees. Hybrid rings. Waveguide corners, Bends and twists, Directional couplers, Circulators and isolators, Windows, Irises, tuning screws. Measurement: frequency, Wave length, VSWR, Impedance, power. Microwave Tubes: Klystron, Reflex Klystron, Magnetron, TWT, BWO: Their schematic, Principle of operation, performance characteristics and application. Semiconductor Devices: Construction, Operation and Practical applications of PIN diode, varactor and Tunnel diode, Gunn diode, IMPATT, TRAPTT diodes, Maser MIC: Introduction to microstrip lines, Parallel Striplines, Coplanar striplines, Shielded striplines, Slot lines, Transitions, Bends and Discontinuities
RECOMMENDED BOOK
1. D. M. Pozar, Micowave Engineering. 4th ed. John Wiley and Sons, Inc.

ECE354: Sensor, Measurement, and Actuators
UNIT I: **SENSORS** Difference between sensor, transmitter and transducer, Primary measuring elements - selection and characteristics: Range; resolution, Sensitivity, error, repeatability, linearity and accuracy, impedance, backlash, Response time, Dead band. Signal transmission - Types of signal: Pneumatic signal; Hydraulic signal; Electronic Signal. Principle of operation, construction details, characteristics and applications of potentiometer, Proving Rings, Strain Gauges, Resistance thermometer, Thermistor, Hot-wire anemometer, Resistance Hygrometer, Photo-resistive sensor. UNIT II: **INDUCTIVE & CAPACITIVE TRANSDUCER** Inductive transducers: - Principle of operation, construction details, characteristics and applications of LVDT, Induction potentiometer, variable reluctance transducer, synchros, microsyn. Capacitive transducers: - Principle of operation, construction details, characteristics of Capacitive transducers – different types & signal conditioning, Applications:- capacitor microphone, capacitive pressure sensor, proximity sensor. UNIT III: **ACTUATORS** Definition, types and selection of Actuators; linear; rotary; Logical and Continuous Actuators, Pneumatic actuator Electro-Pneumatic actuator; cylinder, rotary actuators, Mechanical actuating system: Hydraulic actuator - Control valves; Construction, Characteristics and Types, Selection criteria. Electrical actuating systems: Solid-state switches, Solenoids, Electric Motors- Principle of operation and its application: D.C motors - AC motors - Single phase & 3 Phase Induction Motor; Synchronous Motor; Stepper motors - Piezoelectric Actuator. UNIT IV: **MICRO SENSORS AND MICRO ACTUATORS** Micro Sensors: Principles and examples, Force and pressure micro sensors, position and speed micro sensors, acceleration micro sensors, chemical sensors, biosensors, temperature micro sensors and flow micro sensors. Micro Actuators: Actuation principle, shape memory effects-one way, two way and pseudo elasticity. Types of micro actuators- Electrostatic, Magnetic, Fluidic, Inverse piezo effect, other principles. UNIT V: **SENSOR MATERIALS AND PROCESSING TECHNIQUES** Materials for sensors: Silicon, Plastics, metals, ceramics, glasses, nano materials Processing techniques: Vacuum deposition, sputtering, chemical vapour deposition, electro plating, photolithography, silicon micro machining, Bulk silicon micro machining, Surface silicon micro machining, LIGA process.
RECOMMENDED BOOK(S)
Textbooks: 1. Patranabis. D, “Sensors and Transducers”, Wheeler publisher, 1994. 2. Sergej Fatikow and Ulrich Rembold, “Microsystem Technology and Microbotics”, First edition, Springer –Verlag New York, Inc, 1997.

3. Jacob Fraden, "Hand Book of Modern Sensors: Physics, Designs and Application" Fourth edition, Springer, 2010.

Reference Books:

1. Robert H Bishop, "The Mechatronics Hand Book", CRC Press, 2002.
2. Thomas. G. Bekwith and Lewis Buck. N, Mechanical Measurements, Oxford and IBH publishing Co. Pvt. Ltd.,
3. Massood Tabib-Azar, "Microactuators: Electrical, Magnetic, thermal, optical, mechanical, chemical and smart structures", First edition, Kluwer academic publishers, Springer, 1997.
4. Manfred Kohl, "Shape Memory Actuators", first edition, Springer.

ECE355: Scientific Computing using MATLAB

1. **Fundamental Concepts:** Variables and constants, basic statement structure, input/output, algebraic operations, logic operations, loop control, conditional control, switch, graphical output 2D and 3D.
2. **Matrices and Eigenvalues:** Basic operation and properties of matrices, matrix inversion, generalized matrix inversion, matrix transformation, solving matrix equations, eigenvalues and vector, transformation and diagonalization, power method, Jacobi method,
3. **Linear and Non-**linear equations: Gauss and Gauss-Jordan eliminations, Matrix factorization, iterative method, bisection method, Newton-Raphson method, Secant method.
4. **Calculus Problems:** Solution to limit problems, solution to derivative problems, partial derivatives, partial derivatives of implicit functions, derivative of parametric equations, gradient, divergence and curl, solution to indefinite, definite and improper integral problems, multiple integrals, Taylor and Fourier series expansion, path and line integrals, scalar and vector surface integrals, numerical differentiation, numerical integration.
5. **Differential equations:** Numerical solution of ordinary differential equations, solution of special ordinary differential equations, solution of boundary value problems, Partial differential equation (PDE), Elliptical PDE, Parabolic PDE, Hyperbolic PDE.
6. **Transforms and Complex valued functions:** Laplace transform and their inverse, Fourier transform and their inverse, z transform and their inverse, complex matrices, computation of poles and residues, solution of difference equations.
7. **Data Interpolation:** Interpolation and data fitting of 1D, 2D and higher order, spline interpolation, fitting mathematical models, signal analysis and digital signal processing.
8. **Probability and Statistics:** Probability density function (PDF) and cumulative distribution function (CDF), probability computation of continuous functions, Monte-Carlo solution, random walk problems, mean and variance of stochastic processes, moments of stochastic processes, covariance of multivariate stochastic processes, joint PDFs and CDFs, statistical estimation.

RECOMMENDED BOOK(S)

1. Otto, Stephen Robert, and James P. Denier, “An introduction to programming and numerical methods in MATLAB”, Springer, 2005.
2. Bashier, Eihab BM., “Practical Numerical and Scientific Computing with MATLAB and Python”, CRC Press, 2020.
3. Yang, Won Y., Wenwu Cao, Jaekwon Kim, Kyung W. Park, Ho-Hyun Park, Jingon Joung, Jong-Suk Ro, Han L. Lee, Cheol-Ho Hong, and Taeho Im, “Applied numerical methods using MATLAB”, John Wiley & Sons, 2020.
4. Palm, William John, “Introduction to MATLAB for Engineers”, McGraw-Hill, 2011.

ECE356: RF and Microwave Circuit Design

1. **Introduction:** Frequency spectrum, frequency behaviour of passive components & chip components.
2. **Transmission Line:** Transmission lines, electrical equivalent circuit analysis, sending port impedance, input impedance, voltage standing wave, transmission line matching, smith chart, impedance and admittance transformations, impedance matching networks.
3. **Two-port Networks:** Series and parallel networks, Z-parameter, Y-parameter and h-parameter, S-parameters, X-parameter, ABCD parameters, conversion of different network parameters.
4. **RF Filter Design:** Basics of filter configurations, Butterworth and Chebyshev type filters, Filter design by the Image Parameter method and Insertion Loss method, Implementation of microwave filters.
5. **RF Transistor Amplifier Design:** Amplifier characteristics, Amplifier parameters, stability criteria, Amplifier design for maximum gain, constant gain, noise figure and VSWR circles, Introduction to Doherty amplifier.
6. **RF Oscillators:** Basic oscillator model, negative resistance and feedback oscillator designs, quartz oscillators, electronic tuning of oscillator, phase locked loop.
7. **RF Mixers:** Basic characteristics of mixers, single ended mixers, single balanced

RECOMMENDED BOOK(S)

- **Text Books**

1 Ludwig, R. and Bretchko, P., "RF Circuit Design", Pearson Education, 2000.
2 Misra, D.K., "Radio-frequency and Microwave Communication Circuits", John Wiley & Sons, 2001.

- **Reference Books**

1. Fooks, E.H. and Zakarevicius, R.A., "Microwave Engineering Using Microstrip Circuits," Prentice-Hall, 1990
2. Franco di Paolo, "Networks and Devices using Planar Transmission Lines," CRC Press, 2000.
3. Pozar, D.M., "Microwave Engineering", 3rd Ed., John Wiley & Sons, 2004.
4. Roberto Sorrentino and Giovanni Bianchi, "Microwave and RF Engineering" John Wiley & Sons, 2010.
5. B. Bhat and S. K. Koul, Stripline Like Transmission Lines For Microwave Integrated Circuits New Age Intl. Pvt Ltd., 2007.

ECE357: Introduction to Robotics
1. Sensing, Localization, Mapping, Planning, Control and Actuation. 2. Localization via Kalman/Complimentary Filter, localization with noisy data 3. Mapping via Grid based Mapper, 2D, 2.5D and 3D grid based mapping 4. Planning Via Arc based, Grid based planner and heuristic search. 5. Dynamics and control via PID controller, Joint space control, iterative control for speed and direction of movement 6. Navigation using waypoint follower, navigation in absence of GPS 7. Forward and Inverse Kinematics, Jacobian representation. 8. Basics of Computer vision, spatial descriptions and pose transformations. 9. Basics of Neural networks and robot learning mechanisms 10. Common types of Actuators, motors, and sensors and their principles 11. Navigation mechanisms, differential and skid steering in mobile robots and drones
RECOMMENDED BOOK(S)
• **Text Books** 1. Introduction to Autonomous Mobile Robots, Book by Illah Reza Nourbakhsh and Roland Siegwart 2nd edition 2. Introduction to Robotics: Mechanics and Control, John J. Craig, Addison-Wesley Publishing Company, 3rd Edition, • **Reference Books** 1. Robot Modelling and Control, M. Spong, M. Vidyasagar, S. Hutchinson, Wiley & Sons, 2005. 2. Robotics, Vision, and Control, Peter Corke, Springer, 2011. 3. Introduction to Robotics, P. J. McKerrow, ISBN: 0201182408 4. Modern Robotics: Mechanics, Planning, and Control, Kevin Lynch and Frank Park, Cambridge University Press, 2017. ISBN: 9781107156302.

ECE360: IoT - Architecture, Communication Technology, and Applications
1. **Introduction**: Introduction of IoT, Architectural Overview, Design principles and needed capabilities, IoT applications, Sensing, Actuation, Basics of networking, Wireless sensor networks, M2M and IoT technology, Fundamentals - Devices gateways, Data management, Business processes in IoT, Role of Cloud in IoT, Security aspects in IoT. 2. **Elements of IoT** 3. **Hardware components**- Computing (Arduino/Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces. 4. **Communication Protocols** ZigBee, Bluetooth, Wi-Fi-IEEE802.11a,n,ac,ax,ah,af,p, LPWAN-LoRa, Sigfox, NB-IoT, LTE-M 5. **Software Components**- Programming API's (using Python/Node.js/Arduino) for communication protocols- MQTT, COAP, UDP, TCP 6. **IoT Application Development**: Solution framework for IoT applications:-> Implementation of device integration, Data acquisition and integration, Device data storage- Unstructured data storage on cloud/local server, Authentication, authorization of devices 7. **Cloud, edge, and fog computing** architectures for IoT applications. The OpenFog reference architecture. Case studies from various domains (details TBD). 8. **IoT Case Studies**: IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture, Healthcare, Smart Home, Smart building, Smart City

ECE361: Power System Analysis

1. Per unit system representation. Primitive network, single phase and of three phase.
2. Ybus and Zbus; Building algorithm for the formation of Zbus with coupling.
3. Power system load flow studies, necessity, data requirements, network flow equations both in Polar and rectangular co-ordinates, line flow and line losses; types of busses for load flow; numerical methods of load flow solution- Gauss, Gauss Seidel, Newton Raphson methods in polar and rectangular co-ordinates without and with PV buses; Decoupled, fast decoupled and DC load flows. Their comparisons.
4. Short-circuit analysis of power system; introduction to symmetrical component transformation and obtaining sequence components Generator, Transformer and transmission line impedances; sequence impedance diagrams of network and flow of currents in transformers. Computer methods for the solution of balance and unbalance faults in three phase networks.
5. Power System stability, definition, elementary ideas of steady state, dynamic stability. Surge impedance loading and problems of long transmission lines, series and shunt compensation.
6. Power System transient stability, determination of swing curve, Transient stability using equal area criteria, its limitations, calculation of swing curve by point by point method for single and multi- machine case. Methods to improve transient stability.

RECOMMENDED BOOK(S)

1. D.P. Kothari, I. J. Nagrath, "Power System Engineering", 2nd Edition, Sixteen reprint, 2013 McGraw Hill Education
2. T.N. Nagsarkar, M.S. Sukhija, "Power System Analysis"7th Impression,2012, Oxford Publication
3. M.A. Pai, Dheeman Chatterjee, Third Edition , 5th Reprint, 2017, Mc Graw Hill Education.

ECE362: Digital Communication

1. **Communications Signal and Systems:** Introduction to Digital Communication, Representations of Bandpass Signals and Systems, Inner Product Spaces and Subspaces, Orthonormal bases, Gram Schmidt orthogonalization procedure, Geometric representation of Signals, Signal Space Representation of M-ary Signal Sets.
2. **Review of Random processes and random variables:** Random variables, Some useful probability distributions: Uniform, Exponential, Gaussian, Rayleigh, Transformation of Random variables, expectation, variance. White Gaussian noise process: autocorrelation function and power spectral density, LTI filtering.
3. **Baseband and Passband Digital Data communication:** Baseband digital data transmission in white Gaussian noise: Matched filter and correlation. Passband digital data transmission in noise: Transmission and reception (correlation-based) model. Hierarchy of digital modulation techniques and their constellations: BPSK, QPSK, M-ary QAM, M-ary PSK, Minimum Shift Keying (MSK), Frequency Shift Keying (FSK). Coherent detection of signals: Probability of error and performance comparison. Non-coherent reception and their performance. Intersymbol interference (ISI) and Equalization.
4. **Carrier and Symbol Synchronization:** Importance in signal demodulation, carrier frequency and phase estimation– decision directed and power of N methods, symbol timing estimation– spectral-line, MMSE, and ML methods. Joint carrier and symbol synchronization.
5. **Fundamental Limits of Communication systems:** Channel capacity, Coding and Decoding, Source Coding, Information Measure, Introduction to Error control: Linear Block codes, Convolution Codes, Hamming, and Turbo codes.
6. **Advanced Communication Techniques:** Multichannel communications, Spread spectrum communications, OFDM.

RECOMMENDED BOOK(S)

- **Text Books**

1 John G Proakis and Salehi, Digital Communication, 5th Edition, McGraw-Hill, 2008.
2 Simon Haykin, "Communication Systems", 4th Edition, John Wiley & Sons, 2001.
3 Rodger E. Ziemer and William H. Tranter, "Principles of Communication-Systems, Modulation and Noise", 7th Edition, John Wiley & Sons, 2015.
4 B. P. Lathi, "Modern Digital and Analog Communication Systems", 3rd Edition, Oxford University Press, 1998.

- **Reference Books**

1. John M. Wozencraft and Irwin Mark Jacobs, "Principles of Communication Engineering," Wiley, 1965.
2. John R. Barry, Edward A. Lee, David G. Messerschmitt, Digital Communications, Springer, 3rd Edition, 2004.

ECE363: Computer Communication Networks
Introduction, OSI Layers: the physical layer, the data link layer, the network layer, the transport layer, the session layer, the presentation layer, the application layer. The TCP/IP Architecture: Internet, IPV4, IPV6, Ethernet. WiFi, Cellular Networks: 3G, 4G, 5G, Control of Networks, Mathematical models and Performance analysis of Networks
RECOMMENDED BOOK(S)
1. Computer Networking – A Top-Down Approach by James F. Kurose and Ross, 8th Edition, 2020. 2. High-performance Communication Networks by Jean Walrand and Pravin Varaiya, The Morgan Kaufmann series in networking, 2nd Edition, New Delhi: Elsevier, c2000.

ECE365: Object Oriented Programming
For the C++ variant: 1. **Object oriented analysis and design:** Encapsulation, inheritance, polymorphism, operator overloading 2. **Preprocessor**: Namespaces, macros, conditional compilation, name mangling and interoperability with C 3. **Functions and variables**: Data types, local versus global variables, pointers and references, non-member functions, passing arguments by value versus reference, function overloading, default arguments, inline functions 4. **Structures**: Structures, pointers to structures, poor man's encapsulation using opaque structures 5. **Classes**: Encapsulation, member functions, constructors and destructors, initializers, default constructor, static class members, nested classes, local classes 6. **Inheritance**: **Is-A** relation between base and derived classes, access control and public/protected/private inheritance, multiple inheritance 7. **Streams**: File/display/keyboard input/output 8. **Operator overloading**: Syntactic sugar versus real use 9. **Error handling**: Throwing, catching and propagating exceptions 10. **Templates and Generic programming**: Templates, template parameters 11. **The Standard Template Library (STL)**: Vectors, sets, maps, etc 12. **Program structure**: Introduction to the programming environment, header files, source files, compilation 13. **Debugging**: Breakpoints, stepping through, watch variables, trace variables, stack trace 14. **Miscellaneous**: Choosing a suitable development environment, coding standards, etc
For the Python variant: 1. **Getting started** 2. **Object types:** Python's core data types like numbers, strings, lists, tuple, dictionary 3. **Statements and Syntax:** Statements; assignments, expressions, and print; conditional statements; loops; iterations and comprehensions; the documentation interlude 4. **Functions and Generators:** Basic functions, scopes, arguments, advanced function topics, comprehensions & Generations, the benchmarking interlude 5. **Modules and Packages:** The big picture, module coding basics, module packages, advanced module topics 6. **Classes and OOP:** The big picture, class coding basics, class coding details, operator overloading, designing with classes, advanced class topics
RECOMMENDED BOOK(S)
1. ***C++ Primer***, Stanley Lippman, Josée Lajoie and Barbara Moo; Addison-Wesley, 5th edition 2. Online: https://www.cplusplus.com/

ECE366: Antenna Theory and Wave Propagation

1. **Fundamental Concepts:** Concept of Radiation (physical meaning), Potential functions & Electromagnetic field, Network Theorems, Radiation Pattern, near-field and far-field regions, basic parameters of antenna (directivity, gain, effective aperture, polarization, input impedance, and efficiency), Friis transmission equation, Methods of Excitation.
2. **Radiation from Wires, Loops, Aperture and Microstrip Antennas:** Infinitesimal dipole, finite-length dipole, dipoles for mobile communication, small circular loop. Huygens' principle, radiation from rectangular and circular apertures, design considerations, Babinet's principle, Radiation from sectoral and pyramidal horns, design concepts, Basic characteristics of microstrip antennas, feeding methods, methods of analysis, design of rectangular and circular patch antennas.
3. **Antenna Arrays:** N element linear array, Broadside and End fire array, pattern multiplication, Phased array, Adaptive array, Antenna synthesis- Binomial array.
4. **Special Antennas:** Log-periodic antennas, Spiral Antennas, Helical Antennas, Modern Antenna: Reconfigurable Antenna, Dielectric Resonator Antennas, Active Antennas, Electronic band Gap Structure, Terahertz Antennas.
5. **Radio Wave Propagation:** Modes of propagation, Structure of atmosphere, ground wave propagation, Tropospheric wave propagation, Duct propagation, Tropo-scatter propagation, Flat and curved earth concepts, Sky wave propagation, Virtual height, Critical frequency, Maximum usable frequency, Skip distance, Fading, Multi-hop propagation.

RECOMMENDED BOOK(S)

- **Text Books**

1. Constantine A Balanis, "Antenna theory: Analysis and Design" John Wiley & sons, 2015.
2. Raju, G. S. N. "Antennas and wave propagation", Pearson Education India, 2006.

- **Reference Books**

1. Kraus, John D., Ronald J. Marhefka, and Ahmad S. Khan. "Antennas and wave propagation", Tata McGraw-Hill Education, 2006.
2. Edward C Jordan and Keith G Balmain, "Electromagnetic waves and radiating systems" Pearson Education; Second edition, 2015.

ECE367: Digital Design with FPGAs

Familiarisation with Xilinx Vivado Suite: i) Installation guide and settings for Xilinx Vivado Suite, ii) Description of various tool boxes available with Xilinx Vivado Suite.

Verilog Concepts: i) Review of various design styles in Verilog, ii) Combinational and sequential logic iii) Finite state machine

FPGA Architecture: i) Introduction to various programmable links: PLA, PAL, SPLD, CPLD, FPGA ii) Various FPGA Technologies iii) Generic architecture of FPGA iv) Familiarization of Nexus-4 FPGA board

i) **Introduction to Static Timing Analysis:** STA Basics: What is STA, Purpose of STA, How does STA fit into the Design Flow, What are Timing Libraries, Elements of Static Timing, Introduction to Timing Arcs, Timing Arc Characteristic (Unateness, Slew & Delay).
ii) Understanding Cell and Net Delays: Terminology for Cell and Net Delay, Different kind of Cell Delay, Cell Library Model, and Wire Load Model.
iii) Understanding Clocks: Ideal Clock, Duty Cycle, Clock Skew, Clock Propagation, Clock uncertainty, Latency, and Understanding of Launch and Capture Clock.
iv) Timing Paths & Timing Checks: Understanding Timing Paths: Start point, End Point, Timing Paths Types, Slack, Setup and Hold Time, Setup and Hold Violation, Recovery and Removal, Min Clock period, Path Exceptions: Multi-Cycle paths and false paths.
v) Xilinx Design Constraints (XDC): Design Constraints, Syntax, and Design Objects: Chip, Cell, Block, Pin, Port, Clock, Environmental Constraints, Design Rules, Timing Constraints, Exceptions.

Power Report and IP integration

Design Applications: i) General Design Issues, and ii) Implementation of Memory and FIFO iii) Design for Wireless Communication Systems.

RECOMMENDED BOOK(S)

1. Wayne and Wolf, "FPGA based system Design", 11th edition, Pearson Publishing Private Limited.
2. Samir Palnitkar, "Verilog HDL A guide to Digital Design and Synthesis", SunSoft Press.
3. Clive Maxfield, "The Design Warrior's Guide to FPGA", Elsevier Publishing.
4. Andrew Moore and Ron Wilson, "FPGA for dummies", 2nd special edition by INTEL, Wiley Publishing.

ECE451: Design of CMOS Analog Circuits

1. **CMOS Fundamentals:** MOSFET physics, concept of threshold voltage, body-effect, DC models, small-signal models, MOSFET frequency response
2. **Single-transistor non-differential stages**: Common-source stage (with and without source degeneration), common-drain stage, common-gate stage
3. **Multi-transistor non-differential stages**: Cascode stage, active cascode, super source follower
4. **Differential pairs**: Basic differential pair, DC analysis, small signal analysis, common-mode and differential mode analysis, key metrics like CMRR/PSRR/Z_{in}/Z_{out},/V_{OS}, effect of mismatch on key metrics
5. **Current mirrors**: Simple current mirror, cascode current mirror, high-swing cascode current mirrors, Wilson current mirror
6. **Active loads**: Complementary load, depletion load, diode-connected load, usage in a differential- pair
7. **Current sources**: Widlar current source, Peaking current source, threshold-voltage-referenced current source, concept of sensitivity, supply-sensitivity of current sources, self-biasing and start- up circuits
8. **Bandgap voltage references**: Motivation, temperature sensitivity, general principle, MOS implementation
9. **Case study of a 2-stage single-ended MOS Operational Amplifier**: Schematic, discussion of metrics like input offset voltage, input bias current, input offset current, common-mode input range, CMRR, PSRR, frequency response and slew rate, and the desired design space parameters
10. **Feedback:** Benefits of feedback, canonical treatment of feedback, various feedback styles and their effect on key metrics, modelling the loading by feedback networks
11. **Frequency response theory**: Poles and zeros, Miller effect and its application to a common- source stage, OCTC and SCTC methods for calculating the dominant and most non-dominant pole, application of the OCTC method to a 2-transistor circuit
12. **Frequency response of feedback amplifiers, stability and compensation:** Bode plots, Nyquist criterion for stability, Phase margin, frequency compensation by narrowbanding, adding a pole versus moving a pole, pole-splitting and Miller multiplication, slew rate

RECOMMENDED BOOK(S)

1 **Analysis and Design of Analog Integrated Circuits**, Paul R. Gray, Paul J. Hurst, Stephen H. Lewis and Robert G. Meyer; John Wiley & Sons, 5th edition
2 **Design of Analog CMOS Integrated Circuits**, Behzad Razavi; McGraw Hill Education, 2nd edition

ECE368: Special Topics in Microwave Engineering

Advanced concepts in electromagnetics: uniqueness theorem, volume/surface equivalence theorems. Introduction to integral equations methods (IEM) by using the Huygen's principle and the extinction theorem. Introduction to Green's functions in one and two dimensions, Solving surface integral equations using the method of moments, how to deal with singularities, and use of quadrature rules, Solving volume integral equations using the Method of moments, Introduction to the Finite Element Method (FEM), basis functions in 1 and 2 dimensions , FEM formulations in 1 and 2 dimensions, Introduction to Finite Difference Time Domain methods (FDTD): Yee cells, update equations, stability, FDTD - Accuracy Analysis, Dispersion, Material specifications and Dispersive media , FDTD - Boundary conditions and their implementation, Applications of computational electromagnetics (CEM): Antenna problems, Applications of CEM: Phased array and Wireless System problems, Applications of CEM: Inverse Scattering problems

ECE452: Power System Operation and Control

1. **Economic Operation of Power System:** Fundamental of power flow solutions, Power factor correction, Distribution of load between units within a plant, Distribution of load between plants, The transmission-loss equation, An interpretation of transformation C, Classical economic dispatch with losses, Automatic generation control, Unit commitment, Solving the unit commitment problems.
2. **Load Frequency Control and Control Area Concept:** Automatic load-frequency control of single area systems: Speed-governing system, Hydraulic valve actuator, Turbine-generator response, Static performance of speed governor, Closing the ALFC loop, Concept of control area, ALFC of multi-control area systems (Pool operation): The two area systems, Modelling the Tie-Line, Block diagram representation of two area system, Dynamic response of two area system, Supervisory control and data acquisition (SCADA).
3. **Power System Stability Problems:** Basic concepts and definitions, Rotor angle stability, Synchronous machine characteristics, Power versus angle relationship, Stability phenomena, Voltage stability and voltage collapse, Mid-term and long-term stability, Classification of stability.
4. **Small Signal Stability:** State space concepts, Basic linearization technique, Participation factors, Eigen properties of state matrix, Small signal stability of a single machine infinite bus system, Studies of parametric effect: Effect of loading, Effect of KA, Effect of type of load, Stability improvement by power system stabilizers. Design of power system stabilizers.
5. **Transient Stability:** Time domain simulations and direct stability analysis techniques (extended equal area criterion) Energy function methods: Physical and mathematical aspects of the problem, Lyapunov's method, Modelling issues, Energy function formulation, Potential Energy Boundary Surface (PEBS): Energy function of a single machine infinite bus system, equal area criterion and the energy function, Multi-machine PEBS.
6. **Sub Synchronous Oscillations:** Turbine generator torsional characteristics, Shaft system model, Torsional natural frequencies and mode shapes, Torsional interaction with power system controls: interaction with generator excitation controls, interaction with speed governors, interaction with nearby DC converters, Sub Synchronous Resonance (SSR): Characteristics of series capacitor - compensated transmission systems, Self – excitation due to induction generator effect, Torsional interaction resulting in SSR, Analytical methods, Counter measures to SSR problems.

RECOMMENDED BOOK(S)

1. John. J. Grainger & W. D. Stevenson, "Power System Analysis", Mc Graw Hill Education, Fifteenth Reprint, 2003.
2. O. I. Elgerd, "An Introduction to Electric Energy System Theory", Mc Graw Hill Education, Second Edition, 2013.
3. Prabha Kundur, "Power System Stability and Control", Mc Graw Hill Education, Edition, Twentieth Reprint, 2016.

ECE453: Foundations of Deep Learning

1. Review of Machine Learning Concepts required for the Course.
2. What is Deep Learning? Major architectures of deep neural networks. Applications in Computer Vision, Speech, and Natural Language Processing.
3. Training of Deep Learning Networks.
4. Convolutional Neural Networks (CNN) architecture and design, Backpropagation in convolutional layer, Transfer Learning, Building a CNN Model for CIFAR-10 Data.
5. Autoencoders, Convolutional Autoencoder (CAE) architecture and design. Unsupervised learning using CAE.
6. Sequence Analysis using Recurrent Neural Networks (RNN), LSTM based Recurrent Networks. Challenges in training Recurrent Networks and the Solutions, Back-Propagation Through Time (BPTT).
7. Word Embedding Models for Vector-space Representation of Words: Word2Vec Models. Sequence Analysis to examine Speech and Language. Building a Recurrent LSTM Model for Sentiment Analysis using Twitter Dataset.
8. Understanding the Fundamentals of Deep Reinforcement Learning.

RECOMMENDED BOOK(S)

1. M. Gopal, "Deep Learning: Core Concepts, Methods and Applications", McGraw-Hill, 2022.

2. I. Goodfellow, Y. Bengio and A. Courville, "Deep Learning", The MIT Press, 2016.
3. R. S. Sutton and A. G. Barto, "Reinforcement Learning: An Introduction", 2nd Edition, The MIT Press, 2018.

ECE454: Optical Fiber Communication

Module 1: Optical Fibers

Overview optical communication, other forms of communication systems, Basic elements of optical fiber links, Introduction to vector nature of light, Propagation of light, Ray model and wave model. Optical fiber: Types, Structure and wave guiding fundamentals, Optical fiber modes and analysis, Step and Graded Index Fibers.

Module 2: Losses in Optical Fibers

Signal degradation in Optical fiber due to dispersion and attenuation.

Module 3: Optical sources and detectors

Optical Sources: Basic light emission mechanism in semiconductors, LED and LASERs, Optical Detectors: Basic light absorption concepts in semiconductors, photodiodes, *p-i-n* detectors, detector responsivity, noise, Optical Receivers.

Module 4:

Optical Power Launching and Coupling: Lensing Scheme for coupling improvement, Fiber-to-Fiber Joints, Splicing Techniques, Optical fiber connectors. Design Considerations of Optical fiber Systems: Noise in detection process. Bit error rate. Optical receiver operation. Power Budget and Rise time Budget. WDM.

Module 5: Advanced topics in Optical Communication

Basics of Optical amplifiers, Optical amplifiers and soliton-based Communication, nonlinear effects in optical fiber links.

RECOMMENDED BOOK(S)

- **Textbooks**

1. G. Keiser, Optical Fiber Communications, TMH.
2. Ghatak & K. Thygarajan, Introduction to Fiber Optics, Cambridge.

- **Reference Books**

1. J. Gowar, Optical Communication Systems, PHI.
2. J.M. Senior, Optical Fibre Communications: Principles & Practice, PHI

ECE456: High Voltage Engineering

1. Electric breakdown phenomenon in gases, liquid, and solid insulation materials, generation of high A.C. and D.C. voltages, generation of impulse voltages and currents, measurement of high voltages and currents, high voltage testing of electrical apparatuses, transients in power systems (lightning and switching induced transients), insulation coordination.
2. Numerical computation of the electric field intensity in homogenous and multi-dielectric isotropic materials by using finite element method (FEM).
3. Extra-high voltage (EHV) and ultra-high voltage (UHV) transmission systems, mitigation of audible noise, radio interference, corona loss, and high voltage gradients.

RECOMMENDED BOOK(S)

1. E. Kuffel, W. S. Zaengl, and J. Kuffel, *High Voltage Engineering Fundamentals*. Butterworth-Heinemann, Oxford, 2000.
2. M. S. Naidu and V. Kamaraju, *High Voltage Engineering*. TMH Publications, 2000.
3. R. K. Begumudre, *Extra High Voltage AC Transmission Engineering*. New Age Science Ltd., 2011.
4. C. L. Wadhwa, *High Voltage Engineering*. New Age International Publishers, New Delhi, Second Edition, 2007

ECE457: Information Theory and Coding

Preliminaries

- Axiomatic development of Shannon's entropy and its relevance
- Relative Entropy, fundamental inequality , mutual information
- Jensen's inequality and other information theoretic inequalities
- Entropy rate, Asymptotic Equipartition Property (AEP), Typical Sequences
- Shannon- McMillan - Breiman Theorem.

Source coding (data compression)

- Block to variable length codes, prefix property, Kraft inequality
- Noiseless coding theorem,
- Shannon code, Huffman code and its optimality as a prefix code
- Universal Compression algorithms-
- Lempel - Ziv class universal codes – incremental parsing based LZ 78 and Sliding Window
- Lempel - Ziv (LZ 77) code
- Source coding with distortion (lossy compression),
- Differential entropy, properties and contrast with entropy
- Rate Distortion theorem and its converse

Channel coding: capacity results for discrete memoryless channel, Gaussian channel

- Joint Typicality
- Shannon's Channel Coding Theorem and its weak and strong converse
- Error Correcting codes-
- Parity check codes, cyclic codes
- Channel Coding theorem for parity check codes
- Low density parity check code
- Polar codes (proposed for 5G)

RECOMMENDED BOOK(S)

Textbooks:

1. Thomas M. Cover and Joy A. Thomas, Elements of Information Theory, John Wiley & Sons, 2006.
2. Robert Ash, Information Theory, Reprint by Dover Publications, original 1965 by Wiley Inter science.

ECE458: Radar Communications

Radar and Radar Equation: Introduction, Radar block diagram and operation, frequencies, applications, types of displays, derivation of radar equation, minimum detectable signal, probability of false alarm and threshold detection, radar cross-section, system losses, propagation characteristics over land and sea.

CW Radar – Doppler Effect, CW Radar, applications, FM – CW radar, altimeter, Multiple Frequency Radar. Pulse Radar – MTI, Delay Line Canceller, Multiple Frequencies, Range-gated Doppler Filters, Non-coherent MTI, Pulse Doppler Radar,

Tracking Radar- Sequential lobing, conical scanning, monopulse, phase comparison monopulse, tracking in range, comparison of trackers.

Detection & Estimation – Introduction, Matched Filter, Detection Criteria, Detector characteristics. Electronic countermeasure.

Phased Arrays – Basic concepts, feeds, phase shifters, frequency scan arrays, multiple beams, applications, advantages and limitations. Navigational Aids: Direction Finder, VOR, ILS and Loran

RECOMMENDED BOOK(S)

1. M. I. Skolnik, Introduction Radar Systems, 2nd Edn, McGraw Hill Book Co.,1981
2. F. E. Terman, Radio Engineering, McGraw Hill Book Co. (For Chapter 7 Only), 4th Edn. 1955
3. Simon Kingsley and Shaun Quegan, Understanding Radar Systems, McGraw Hill Book Co., 1993.
4. Nathanson, F E, "Radar Design Principles" Scitech Publishing.
5. Hovanessian, S.A., "Radar System Design and Analysis", Artech House
6. D.K.Barton, Modern Radar Systems Analysis, Artech House, 1988.

ECE459: Computational Electromagnetics
1. **Fundamental Concepts:** Review of EM theory, Electrostatic Fields, Magnetostatic Fields, Time varying Fields, Boundary conditions, Wave Equations, Vector Potentials, Network Theorems, Classical Differential Equations, Classical Boundary Conditions 2. **Analytical Methods:** Separation of Variables, Separation of variables in rectangular coordinate and related examples, Separation of variables in cylindrical coordinate and related examples, Separation of variables in spherical coordinate and related examples, 3. **Finite Difference Method**: Basics of Finite Difference Method, Finite-Difference-Time-Domain Method, Stability and Accuracy, Practical application examples, Absorbing boundary Conditions, 4. **Finite Element Method:** Introduction, Solution of Laplace's Equation, Solution of Poisson's Equation
RECOMMENDED BOOK(S)
• Computation Electromagnetics with MATLAB by Matthew N. O. Sadiku, fourth edition, CRC press • The Finite Difference Time Domain Method for Electromagnetics by Karl S Kunz, CRC Press. • Theory and Computation of Electromagnetic fields by Jian-Ming Jin, John Wiley & Sons

ECE460: Power System Protection and Switchgear

1. **Introduction of Protection Schemes**: Principles of power system protection, Faults and abnormal operating conditions, classification of shunt faults, protection system attributes, system transducers, introduction of current transformer and potential transformer.

2. **Over-current Protection of Transmission Lines**: Over-current relay and its types viz. Instantaneous over-current relay, definite time over-current relay, inverse time over- current relay, inverse definite minimum time over-current relay, very inverse and extremely inverse over-current relays, directional over-current relay and their applications.

3. **Distance Protection of Transmission Lines**: Impedance relay, reactance relay, mho relay, effect of arc resistance on the reach of distance relays, distance protection of three phase transmission lines, three-stepped distance protection scheme, carrier-aided protection scheme of transmission lines.

4. **Differential Protection**: Simple differential protection scheme, behaviour during internal and external faults, zone of protection of the differential relay, through fault stability, percentage differential relay, earth leakage protection, transformer protection, percentage differential relay with harmonic restraint, Buchholz relay, generator protection, protection under loss of excitation, induction motor protection, single phasing, phase faults, ground faults.

5. **Circuit Breakers**: Isolators and circuit breakers, arc generation phenomenon, arc interruption theories, restriking and recovery voltages, rate of rise of recovery voltage, current chopping phenomenon, rating of circuit breaker, types of circuit breakers viz. air blast circuit breaker, vacuum circuit breakers, oil circuit breakers, SF6 circuit breaker, MCB, ELCB/RCCB.

RECOMMENDED BOOK(S)

- **Textbooks**
  1. Fundamentals of Power System Protection by Y. G. Paithankar and S. R. Bhide, 2nd Edition, PHI Learning.
  2. Switchgear, Protection and Power Systems by S. R. Rao, Khanna Publishers.
  3. Electrical Power Systems by C. L. Wadhwa, 3rd Edition, New Age International Ltd.
  4. Modern Power System Analysis by D. P. Kothari and I. J. Nagrath, Tata McGraw Hill.

ECE461: HVDC Transmission

1. **Introduction to Line Commutated HVDC**: HVDC applications, Comparison of AC and DC Transmission, Line-commutated HVDC components, LCC HVDC Topologies.
2. **Thyristor Converters:** Three-phase uncontrolled bridge, three-phase Thyristor rectifier, Analysis of commutation overlap in Thyristor converter, Active and reactive power in a three phase Thyristor converter, Inverter operation, Analysis of 12-Pulse converter.
3. **Analysis of HVDC Converter:** Equivalent circuit of rectifier bridge, Equivalent circuit of Inverter bridge, HVDC equivalent circuit.
4. **Converter Control Characteristics:** HVDC V-I operating diagram, HVDC power reversal, Constant extinction angle (CEA) control, Constant current (CC) control, modification of inverter characteristics.
5. **HVDC Interaction with AC systems:** Influence of converter extinction angle, Influence of reactive power compensation, power transfer between two AC systems, Systems dynamics with low short circuit ratio.
6. **Fault Management and HVDC System Protection:** DC line faults, overvoltage protection, AC line faults.
7. **HVDC System Harmonics:** Thyristor converter harmonics, Harmonic filters.
8. **HVDC with Voltage Source Converters:** Voltage source converter (VSC) HVDC applications and topologies, performance and cost comparison with LCC HVDC, Introduction to multilevel VSC converters.
9. **Cables for HVDC Transmission:** Underground and undersea cable transmission, different HVDC cable types, HVDC cable insulation.

RECOMMENDED BOOK(S)

1. K. R. Padiyar, *HVDC Power Transmission Systems*. New Age International Publishers, New Delhi, Second Edition, 2012.
2. T. Gonen, *Electric Power Transmission System Engineering: Analysis and Design*. CRC Press, Taylor and Francis Group, New York, 2009.
3. D. Jovcic and K. Ahmed, *High Voltage Direct Current Transmission: Converters, Systems and DC Grid*. John Wiley Publishers, 2015.

ECE369: Information Theory

- Axiomatic development of Shannon's entropy and its relevance,
- Relative Entropy, fundamental inequality, mutual information
- Jensen's inequality and other information theoretic inequalities,
- Entropy rate, Asymptotic Equipartition Property (AEP), Typical Sequences,
- Shannon- McMillan - Breiman Theorem.
- Data Compression: Block to variable length codes, prefix property, Kraft inequality, noiseless coding theorem,
- Shannon code, Huffman code and its optimality as a prefix code,
- Variable to fixed length codes, Tunstall code and its asymptotic optimality
- Variable to variable length codes,
- Universal Compression algorithms
- Lempel - Ziv class of codes - LZ 78 and its optimality,
- Sliding Window Lempel - Ziv (LZ 77) code
- Application of LZ codes to hypothesis testing and change detection
- source coding with distortion,
- Differential entropy, properties and contrast with entropy, applications
- Rate Distortion Theory, Rate Distortion theorem and its converse,
- Channel capacity- Discrete Memoryless Channel, Gaussian channel, Joint Typicality,
- Shannon's Channel Coding Theorem and its converse Review of point-to point digital communication over LTI channel
- Wireless channel models
- Capacity of wireless channel
- Performance of digital modulation schemes over wireless channel
- Multi-antenna beam forming and diversity
- Multi-input multi-output (MIMO) Communication system principles
- Mutiple Access Schemes: OFDMA, CDMA
- Introduction to Multi-user systems
- Emerging technologies: 4G, 5G

RECOMMENDED BOOK(S)

- **Textbooks**

1. Robert Ash, "Information Theory", Reprint by Dover Publications, original 1965 by Wiley Inter science.
2. Thomas M. Cover and Joy A. Thomas, "Elements of Information Theory", John Wiley & Sons, 2006.

ECE370: Wireless Communications

- Review of point-to point digital communication over LTI channel
- Wireless channel models
- Capacity of wireless channel
- Performance of digital modulation schemes over wireless channel
- Multi-antenna beam forming and diversity
- Multi-input multi-output (MIMO) Communication system principles
- Mutiple Access Schemes: OFDMA, CDMA
- Introduction to Multi-user systems
- Emerging technologies: 4G, 5G

RECOMMENDED BOOK(S)

- **Textbooks**

1. Wireless Communications by Andrea Goldsmith.

- **Reference Books:**

1. Fundamentals of Wireless Communications by David Tse and Pramod Viswanath (2005) Cambridge University Press.
2. Principles of Mobile Communication by Gorden L. Stuber (2017) Springer.
3. Wireless Communications by Andreas F. Molisch (2011) Wiley.
4. Principles of Modern Wireless Communication Systems: Theory and Practice by Aditya Jagannatham (2016) McGraw-Hill Education.

ECE371: Detection and Estimation

1.Introduction
2. Hypothesis Testing
3. Binary Hypothesis Testing
4. Multiple Hypothesis Testing
5. Composite Hypothesis Testing
6. Signal Detection
7. Convex Statistical Distances
8. Performance Bounds for Hypothesis Testing
9. Large Deviations and Error Exponents for Hypothesis Testing
10. Sequential and Quickest Change Detection
11. Detection of Random Processes
12. Bayesian Parameter Estimation
13. Minimum Variance Unbiased Estimation
14. Information Inequality and Cramér–Rao Lower Bound
15. Maximum Likelihood Estimation
16. Signal Estimation

RECOMMENDED TEXT BOOK(S)

- **Textbooks:**
  1. Statistical Inference For Engineers And Data Scientists by P. Moulin and V. Veeravalli, Cambridge University Press (2019).
  2. Principles of Signal Detection and Parameter Estimation by B. C. Levy, Springer (2008).
  3. Fundamentals of Statistical Signal Processing, Volume I: Estimation by S. M. Kay, Prentice Hall (1993).
  4. Fundamentals of Statistical Signal Processing, Volume II: Detection by S. M. Kay, Prentice Hall (1993).
  5. An Introduction to Signal Detection and Estimation by H. V. Poor, Springer (1998).
  6. Detection, Estimation, and Modulation Theory: Part 1 by H. L. Van Trees, John Wiley and Sons (2004).

ECE372: Modern Control Systems

1. **State Space Analysis and Design in Continuous Time**: Controllability and observability, State feedback and state estimator design, Pole placement and observer design, Full-state feedback control.

2. **Introduction to Digital Control and Discrete-Time Systems and Difference Equations:** Basics of digital control systems, Advantages and disadvantages of digital control, Sampled-data systems and discretization of continuous-time systems, Discrete-time signals and sequences, Z-transform and its properties, Transfer functions in the Z-domain.

3. **Digital Controllers and State-Space Analysis in Discrete-Time:** Design of digital controllers using difference equations, PID controllers in the discrete-time domain, Discrete-time system modeling using state-space representation, Controllability and observability in discrete-time, State feedback and state estimator design.

4. **Lyapunov Stability Analysis:** Introduction to Lyapunov's Direct Method, Lyapunov stability definitions: asymptotic stability, stability in the sense of Lyapunov, and exponential stability, Lyapunov functions and their role in stability analysis.
5. **Kalman Filter:** Overview of Kalman filtering and its significance, The classical linear Kalman filter for linear systems, Application of the Kalman filter to estimate the state of linear dynamic systems.

RECOMMENDED TEXT BOOK(S)

- **Textbooks:**
  1. K. Ogata, Modern Control Engineering. Prentice Hall India Learning Private Limited, 5th edition, 2015.
  2. K. Ogata, Discrete-Time Control Systems. Prentice Hall India Learning Private Limited, 2nd edition, 2005.

- **Reference Books:**
  1. Dorf and Bishop, Modern Control Systems. Pearson, 13th Edition, 2016.
  2. Karl J. Åström and Björn Wittenmark, Computer Controlled Systems: Theory and Design. Dover Publication, 3rd edition, 2012.

3. Panos J. Antsaklis and Anthony N. Michel, A Linear Systems Primer. Birkhäuser, 2007th Edition, 2007
4. Franklin, Powell and Emami-Naeini, Feedback Control of Dynamic Systems. Pearson, 8th Edition, 2018.
5. Franklin G. F., Powell J. D., Workman M., Digital Control of Dynamic Systems. Addison-Wesley, 3rd Edition, 1997.

ECE373: Wireless Network Security

1. Security in cellular Devices: Security in GSM, LTE, and 5G networks, Security issues in mobile devices and femtocells.
2. Security in WLAN, WMAN, WiMax: Security goals, Security issues, Threat Types, Countermeasures
3. Security in Ad hoc vehicular Networks: Architecture, Communication Protocols, Privacy and Secure Positioning
4. Security in wireless sensor networks: secure key managements, secure routing protocols, location privacy protections, secure data aggregation, security architecture, cryptographic approaches, resilience on key management, trust management.
5. Security in wireless mesh networks: Vulnerabilities, defence mechanisms, security standards and products
6. Security in RFID Networks: Security requirements, Hardware based solutions, protocol-based solutions, security in commercial RFID devices.
7. Introduction to Cryptography: Introduction to cryptography, Cryptographic Techniques: Plain Text and Cipher Text, Substitution Techniques, Transposition Techniques, Encryption and Decryption, Symmetric and Asymmetric Key Cryptography, Steganography, Key Range and Key Size, Possible Types of Attacks, Algorithms for encryption and decryption.
8. Physical Layer Security: Need pf Physical layer security, Physical-layer threats, jamming techniques, eavesdropping, performance evaluation with and without CSI.

RECOMMENDED TEXT BOOK(S)

- **Text Books:**

1. Lei Chen, Jiahuang Ji, Zihong Zhang (auth.) - Wireless Network Security Theories and Applications-Springer Berlin Heidelberg (2013).
2. Panos C. Lekkas, Randall K. Nichols - Wireless security models, threats, and solutions- McGraw-Hill Professional (2001).
3. Yulong Zou, Jia Zhu (Auth.) - Physical-Layer Security for Cooperative Relay Networks - Springer International Publishing (2016).

- **Reference Books:**

1. Wolfgang Osterhage - Wireless Network Security_ Second Edition-CRC Press (2018).
2. Matthieu Bloch, João Barros - Physical-Layer Security From Information Theory to Security Engineering-Cambridge University Press (2011).
3. Yang Xiao, Xuemin (Sherman) Shen, Ding-Zhu Du - Wireless Network Security- Springer (2007).

ECE374: Reconfigurable Computing

1. Introduction to reconfigurable computing: General Purpose Computing, Domain Specific Computing, Application Specific Computing, Reconfigurable Computing, Fields of application.
2. Reconfigurable Architectures: Simple Programmable Logic Devices, Complex Programmable Logic Device, Field Programmable Gate Arrays, Fine-Grained and Coarse- Grained Reconfigurable architectures.
3. Implementation and Programming Reconfigurable Systems: Integration, FPGA Design Flow, Logic Synthesis, Static reconfigurable systems, Run Time Reconfiguration.
4. High-Level Synthesis and Mapping: Modelling, Temporal Partitioning Algorithms, Mapping to

LUTs of Different Input Sizes, Mapping to Complex Logic Blocks, Mapping Logic to Embedded Memory Blocks, Mapping to Macrocells.

5. Temporal Placement: Offline Temporal Placement, Online Temporal Placement, Managing the Device's Free Space with Empty Rectangles, Clustering, Partition-based Placement.

6. On-line communication: Direct Communication, Communication Over Third Party, Bus-based communication, Network on Chip, The Dynamic Network on Chip.

7. Reconfiguration Management and Partial reconfiguration design: Configuration Architectures-Single-context, Multi-context, Partially Reconfigurable, Relocation and Defragmentation, Pipeline reconfigurable, Block Reconfigurable, Partial Reconfiguration on Virtex Devices, Creating Partially Reconfigurable Designs.

RECOMMENDED TEXT BOOK(S)

- **Text Books:**

1 Christophe Bobda- Introduction to Reconfigurable Computing: Architectures, Algorithms and Applications, Springer Dordrecht, 2007.

2 Scott Hauck, André DeHon, Reconfigurable Computing - The Theory and Practice of FPGA Based Computation, The Morgan Kaufmann Series in Systems on Silicon, 2008.

- **Reference Books**

1. R Vaidyanathan, Trahan Jerry, Dynamic Reconfiguration: Architectures and Algorithms, L Kluwer Academic, 2003.

ECE375: Quantum Computing

1. Quantum Axioms
2. Quantum Gates
3. Quantum Algorithms: Deutsch-Jozsa Algorithm, Quantum phase estimation, QFT, Shor's factorization of numbers, Grover's algorithm, HHL Quantum Algorithm.
4. Computability, complexity theory.
5. Quantum Error Correction Codes: CSS, Stabilizer codes
6. Quantum Cryptography: QKD
7. General Quantum Axioms, Entanglement
8. Quantum State Detection.
9. Quantum Machine Learning
10. Programming based on Qiskit

RECOMMENDED TEXT BOOK(S)

- **Text Books:**

1. Kaye, Laflamme, Mosca, Introduction to Quantum Computing, Oxford 2007.
2. Rieffel and Polak, Quantum Computing, MIT Press, 2011.
3. Nielsen and Chuang, Quantum Computation and Quantum Information, 2000.
4. W. Scherer, Math of Quantum Computing-an Introduction, Springer, 2019.
5. M. Schuld and F. Petruccione, Machine Learning with Quantum Computers, 2nd ed. Springer, 2021