B.TECH.

ELECTRONICS AND COMMUNICATION ENGINEERING

CURRICULUM w.e.f. 2025-26

(also applicable to UG students admitted in year 2024 onwards)

Program Outcomes (POs)

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

Program Specific Outcomes (PSOs)

1. Apply the fundamentals of mathematics, science and engineering knowledge to analyze and design electronic and communication systems, components and processes to meet desired needs within realistic constraints.
2. Use the techniques, skills, and modern engineering tools necessary for engineering practice in inter disciplinary area.

Programme Educational Objectives

The educational objectives of the undergraduate programme of Electronics & Communication Engineering at PEC are:

1. Graduates will have strong engineering knowledge and technical competence to use techniques and skills that allow them to work effectively as electronics and communication engineers in diversified sections of industry, government organizations, public sector undertaking or as an entrepreneur for a successful professional career.

2. Graduates will be actively pursuing higher education for professional development.

3. Graduates will have the motivation for perennial learning and progress their careers by exhibiting leadership qualities with demonstrable attributes in lifelong learning to contribute to the societal needs.

CREDITS BREAK-UP FOR B.TECH. PROGRAMME w.e.f 2025-26 session (Applicable to UG students admitted in the 2024-25 also)

CURRICULAR COMPONENTS	**Institute Existing Credits Breakup (2023-24)**	**Proposed Credits Breakup (2024-25)**
(A) Institute Core Courses (ICC) a) Basic Sciences (BSC) b) Engineering Sciences (ESC) c) General Science (GSN)	 16 20 02	 16 20 02
Total	**38**	**38**
(B) **Humanities, Communication and Management Elective Courses (HSSMEC)**	12	9 + 3[#]
(C) Department Core Courses (DCC)	56	56
(D) Departmental Elective Courses (DEC)	16	16
(E) Institute Open Elective Courses (OEC)	12	8 + 3[$]
(F) Projects (Minor/ Major Project-I & II)	12	12
(G)Internship/ Course Work* (4 credits of Deptt. Elective + 4 credits of Open Elective + 4 credits of Project Work) * **Optional**	12	12
(H) Non-Academic Courses (NAC)	4	4
Grand Total (For those who **do not opt** for Honours/Minor Specialization)*****	162	161
(I) Honours/ Minor Specialization	12/18	12/18
Grand Total (For those who **opt** for degree with Honours/Minor Specialization)	162+ 12/18	161+12/18

EVC Course by Wadhwani Foundation.,
$ Mandatory Open Elective course(s) to be taken from MOOCs platform

Semester wise Revised UG Scheme to be implemented w.e.f. 2025-26 session (Applicable to UG students admitted in the 2024-25 also)

S.No.	SEMESTER-I	Credits
1	Orientation	1
2	Introduction to Discipline Engineering	1
	SEMESTER-I (Pool A/ Pool B)	
3	BSC-I (Mathematics)	4
4	BSC-II(Physics) / BSC-IV Chemistry)	4
5	Environmental Science/ Universal Human Values	1
6	ESC-I/ESC-II ***	4
7	HSM-I/ ESC-III & ESCVII***	3/2&2
8	ESC-V(or ESC-VI)/ESC-IV	4
	TOTAL	**22/23**

SEMESTER-II (Pool A/ Pool B)		
S.No.		**Credits**
1	BSC-III (Mathematics)	4
2	BSC-IV (Chemistry)/ BSC-II (Physics)	4
3	Universal Human Values / Environmental Science	1
4	ESC-II/ ESC-I***	4
5	ESC-III & ESCVII ***/ HSM-I	2&2/3
6	ESC-IV/ ESC-V (or ESC-VI)	4
	TOTAL	**21/20**

SEMESTER-III		
S.No.		**Credits**
1	***EVC by Wadhwani Foundation* (HSM-II)**	3
2	Deptt Core Courses (DCC)	16
3	***OE-I (MOOCs course)***	**3**
	TOTAL	**22**

SEMESTER-IV		
S.No.		**Credits**
1	Deptt Core Courses (DCC)	24
	TOTAL	**24**

SEMESTER-V		
S.No.		**Credits**
1	Deptt Core Courses (DCC)	16
2	Minor Project	4
	TOTAL	**20**

SEMESTER-VI		
S.No.		**Credits**
1	**Internship Training (Optional)**	12
	Students opting for course work will do Deptt. Elective (4 credits), Open Elective (4 credits) and Project Work (4 credits)	
	TOTAL	**12**

SEMESTER-VII		
S.No.		**Credits**
1	HSM-III	3
2	DEC-I	4
3	DEC-II	4
4	OE-II	4
5	Major Project-I	4

SEMESTER-VIII		
S.No.		**Credits**
1	HSM-IV	3
2	DEC-III	4
3	DEC-IV	4
4	OE-III	4
5	Proficiency	2

	TOTAL	**19**
ABBREVIATIONS		
Basic Science Course		BSC
Engineering Science Course		ESC
Humanities, Social Sciences & Mgmt.		HSM

6	Major Project-II*	4
	TOTAL	**21**
ABBREVIATIONS		
Department Core Course		DCC
Department Elective Course		DEC
Open Elective Course		OE

Total Credits = 161 without Honors/Minor Specialization

Honours Degree

Semester		**Credits**
V	Honours Project-I	3
VII	Honours Project-II*	4
VIII	Honours Project-III**	5
	TOTAL	**12**

Minor Specialization

Semester		**Credits**
III	Minor Specialization Course-I	4
IV	Minor Specialization Course-II	4
V	Minor Specialization Course-III	4
VII	Minor Specialization Project-I	3
VIII	Minor Specialization Project-II*	3
	TOTAL	**18**

Total Credits = 161 + 12/18 with Honors/Minor Specialization

* It is proposed that 'A+' grade should only be given to students who have at least one paper accepted/published in refereed Journal or full-length papers published in peer reviewed conferences organized by IISC/IIT/NIT/IIIT/Premier R&D organizations/ Professional societies or any patent published or first 3 position holders in any reputed national hackathons or project competitions or participation in International hackathons or project competitions.

** It is proposed that 'A+' grade should only be given to students who have at least one paper accepted/published in SCI/SCIE/SSCI/Web of Science/SCOPUS Indexed Journals or any patent published or first 3 position holders in any reputed national hackathons or project competitions or participation in international hackathons or project competitions.

*** The following ESC courses are proposed to be mandatory for all branches: -

i. Introduction to Computer Programming (ESC-I)
ii. Engineering Drawing with CAD software (ESC-II)
iii. Skill Development Workshop (IoT& Sensor/Drone Technology etc.) (ESC-III)
iv. Introduction to Mechatronics (ESC-IV)
v. Introduction to Product Design (ESC-VII)

HONOURS / MINOR SPECIALIZATION PROGRAMME

Students with good academic performance (having CGPA $\geq$ 8.5 for Honours and CGPA $\geq$ 7 for Minor specialization) and desirous of excelling further in academics have the following opportunities:

a) **Honours:** To get Honours in the parent discipline, a student will have to earn additional 12 credits (over and above 161 credits) in the parent department.

b) **Minor Specialization:** To get Minor specialization, a student will have to complete 18 credits (over and above 161 credits) by doing courses outside the parent department during the entire duration of the programme in the institute.

Honours/ Minor specialization will be awarded to a student on the recommendation of the DAPC of the parent department. A student may do Honours, Honours with Minor Specialization OR Minor Specialization only.

Semester-wise Scheme B.Tech.
Electronics and Communication Engineering
1ST TO 8TH SEMESTER
2023-24 ONWARDS

SEMESTER-I						
S.No.	**Course ID**	**Course Name**	**L**	**T**	**P**	**Credits**
1	OR2301	Orientation	-	-	-	1
2	OR2302	Introduction to Discipline Engineering	1	0	0	1
3	MA2301	Calculus	3	0	2	4
4	CH2301	Applied Chemistry-I (ECE, VLSI, M&C & AI)	3	0	2	4
5	GS2302	Universal Human Values	1	0	0	1
6	ES2302	Engineering Drawing with CAD Software	2	0	4	4
7	ES2303	Skill Development Workshop	0	0	4	2
8	ES2307	Introduction to Product Design	0	0	4	2
9	ES2304	Introduction to Mechatronics	3	0	2	4
	Total					23

SEMESTER-II						
S.No.	**Course ID**	**Course Name**	**L**	**T**	**P**	**Credits**
1	MA2302	Linear Algebra, Differential Equations and Vector Calculus	3	0	2	4
2	PY2301	Electromagnetic Theory and Quantum Physics (ECE, VLSI, M&C & AI)	3	0	2	4
3	ES2301	Introduction to Computer Programming	3	0	2	4
4	GS2301	Introduction to Environmental Sciences	1	0	0	1
5	HS2351	Communication Skills	2	0	2	3
6	ES2305	Introduction to Electronics & Electrical Engineering (Aero, ECE & VLSI, AI & M&C)	3	0	2	4
	Total					20

SEMESTER-III						
S No.	**Course ID**	Course Name	L	T	P	Credits
1	EXN301	Digital Logic Design	3	0	2	4
2	EXN302	Electronic Devices and Circuits	3	0	2	4
3	EXN303	Probability and Random Processes	3	1	0	4
4	EXN304	Circuit Theory	3	1	0	4
5		EVC by Wadhwani Foundation (HSM-II)				3
6		OE-I (MOOCs course)				3
Total						22

SEMESTER-IV						
S No.	**Course ID**	**Course Name**	L	T	P	Credits
1	EXN401	Analog and Digital Communication	3	0	2	4
2	EXN402	Analog Electronics	3	0	2	4
3	EXN403	Signals and Systems	3	1	0	4
4	EXN404	Control Systems	3	1	0	4
5	EXN405	CMOS Digital VLSI Design	3	0	2	4
6	EXN406	Microprocessors and Microcontrollers	3	0	2	4
Total						24

SEMESTER-V						
S.No.	**Course ID**	**Course Name**	**L**	**T**	**P**	**Credits**
1	EXN501	Microwave and Radar	3	0	2	4
2	EXN502	Computer Architecture	3	1	0	4
3	EXN503	Digital Signal Processing	3	0	2	4
4	EXN504	Mobile Communication	3	0	2	4
5	EXP511	Minor Project	0	0	8	4
		Total				20

SEMESTER-VI						
S.No.	**Course ID**	**Course Name**	L	T	P	Credits
1	EXN601	Internship Training Part-I	0	0	12	6
2	EXN602	Internship Training Part-II	0	0	4	2
3	EXN603	Internship Training Part-III	0	0	8	4
Or Optional Course Work						
1		Deptt. Elective Course-V	3	1/0	0/2	4
2		Open Elective	3	1	0	4
3	EXP601	Project Work	0	0	8	4
		Total				12

SEMESTER-VII						
S.No.	**Course ID**	**Course Name**	**L**	**T**	**P**	**Credits**
1		HSM-III/ HSM-IV				3
2		Deptt. Elective Course-I				4
3		Deptt. Elective Course-II				4
4		Open Elective –I	3	1	0	4
5		Open Elective-II	3	1	0	4
6	EXP701	Major Project-I	0	0	8	4
		Total				23

SEMESTER-VIII						
S.No.	**Course ID**	**Course Name**	**L**	**T**	**P**	**Credits**
1		HSM-IV/ HSM-III				3
2		Deptt. Elective Course-III				4
3		Deptt. Elective Course-IV				4
4		Open Elective –III	3	1	0	4
5		Proficiency				2
6	EXP801	Major Project-II	0	0	8	4
		Total				21

MINOR SPECIALIZATION IN ELECTRONICS ENGINEERING*

S.No	Semester	Course ID	Course Name	L	T	P	Credits
1	III	ECM101	Analog and Digital Electronics (for non-circuital)	3	0	2	4
		ECM102	CMOS Digital VLSI Design (for circuital)				
2	IV	ECM103	Communication Systems	3	0	2	4
3	V	ECM104	Microcontrollers and their applications	3	0	2	4
4	VII	ECM105	Minor Specialization Project-I	0	0	6	3
5	VIII	ECM106	Minor Specialization Project-II	0	0	6	3
			Total				**18**

*These courses will not be offered to B.Tech Electronics Engineering (VLSI Design and Technology)

Honours Degree

S.No	Course ID	Semester	Course Name	L	T	P	Credits
1	ECH101	V	Honours Project-I	0	0	6	3
2	ECH102	VII	Honours Project-II	0	0	8	4
3	ECH103	VIII	Honours Project-III	0	0	10	5
			Total				**12**

LIST OF DEPARTMENTAL CORE COURSES

S. No.	Course ID	Department Core Course (DCC)	L	T	P
1	EXN301	Digital Logic Design	3	0	2
2	EXN302	Electronic Devices and Circuits	3	0	2
3	EXN303	Probability and Random Processes	3	1	0
4	EXN304	Circuit Theory	3	1	0
5	EXN401	Analog and Digital Communication	3	0	2
6	EXN402	Analog Electronics	3	0	2
7	EXN403	Signals and Systems	3	1	0
8	EXN404	Control Systems	3	1	0
9	EXN405	CMOS Digital VLSI Design	3	0	2
10	EXN406	Microprocessors and Microcontrollers	3	0	2
11	EXN501	Microwave and Radar	3	0	2
12	EXN502	Computer Architecture	3	1	0
13	EXN503	Digital Signal Processing	3	0	2
14	EXN504	Mobile Communication	3	0	2

LIST OF DEPARTMENTAL ELECTIVE COURSES

S. No.	Course ID		Department Elective Course (DEC)	L	T	P
1	DEC I	ECE105	Computer Networks	3	0	0
2		ECE106	Semiconductor Material Synthesis & Characterization	3	0	2
3		ECE107	Analog & Mixed IC Design	3	1	0
4		ECE108	Neural Networks	3	1	0
5	DEC II	ECE109	Optical Communication	3	0	2
6		ECE110	Semiconductor Memories	3	0	2
7		ECE111	VLSI Technology	3	0	2
8		ECE112	Advanced Microprocessors and Microcontrollers	3	1	0
9	DEC III	ECE113	Antenna Theory	3	0	2
10		ECE114	Semiconductor Package Manufacturing	3	1	0
11		ECE115	HDL Based System Design	3	0	2
12		ECE116	Embedded Systems Design	3	0	2
13	DEC IV	ECE117	Satellite Communication	3	1	0
14		ECE118	MEMS-based sensors and actuators	3	0	2
15		ECE119	VLSI Verification & Testing	3	0	2
16		ECE120	Digital Image Processing	3	0	2
17	DEC V (for 6th Semester students)	ECE101	Information Theory and Coding	3	1	0
18		ECE102	Semiconductor Device Modelling	3	1	0
19		ECE103	Measurement Techniques	3	0	2
20		ECE104	FPGA and ASICs	3	1	0

LIST OF OPEN ELECTIVE COURSES

S. No.	Semester	Course ID	Open Elective Course (OE)	L	T	P
1	VI	ECO101	ARDUINO Programming and Raspberry Pi	3	1	0
2	VII	ECO102	Computer Networks	3	1	0
3	VII	ECO103	Semiconductor Package Manufacturing	3	1	0
4	VIII	ECO104	Neural Networks	3	1	0

LIST OF MINOR SPECIALIZATION COURSES

Minor specialization in Electronics Engineering*

S.No.	Semester	Course ID	Minor Specialization Courses	L	T	P
1	III	ECM101	Analog and Digital Electronics (for non-circuital)	3	0	2
		ECM102	CMOS Digital VLSI Design (for circuital)			
2	IV	ECM103	Communication Systems	3	0	2
3	V	ECM104	Microcontrollers and their applications	3	0	2
4	VII	ECM105	Minor Specialization Project-I	0	0	6
5	VIII	ECM106	Minor Specialization Project-II	0	0	6

* These courses will not be offered to B.Tech Electronics Engineering (VLSI Design and Technology)

DEPARTMENTAL CORE COURSES

Course Name	**:**	**DIGITAL LOGIC DESIGN**
Course ID	**:**	**EXN301**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:

Students should be able-

- To apply the rules and laws of Boolean algebra in logic analysis and design.
- To explore the principles and methodology of digital logic analysis and design at the gate level, including both combinational and sequential logic elements.
- To explain the characteristics of different types of memories, logic families, analog to digital, and digital to analog converters.
- To develop digital circuits through laboratory and simulation experiments.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
Unit 1	**DIGITAL FUNDAMENTALS:** Theorems of Boolean algebra, Sum of Products and Products of Sum forms, Boolean function minimization, Logic gates, Universal building blocks- NAND and NOR gates	5
Unit 2	**COMBINATIONAL LOGIC:** Review of Arithmetic circuits, Parallel binary adder, Combined adder-subtractor, BCD adder-subtractor, binary multiplier, magnitude comparator, code converter, encoder-decoder, function realization using multiplexer- demultiplexer, parity detector and generator, three state gate	6
Unit 3	**INTRODUCTION TO VHDL:** Behavioral – data flow, and algorithmic and structural description, lexical elements, data objects types, attributes, operators; VHDL coding examples, combinational circuit design examples in VHDL and simulation	5
Unit 4	**SYNCHRONOUS SEQUENTIAL LOGIC:** Latches and Flip Flops (SR, D, JK, T), Timing in sequential circuits, Shift registers, Counters – synchronous and asynchronous, Synchronous Sequential circuit analysis and design, Finite state machines	9
Unit 5	**ASYNCHRONOUS SEQUENTIAL CIRCUITS:** Analysis Procedure, Circuits with latches; Design Procedure, Reduction of state and flow table; Race free state assignment	5
Unit 6	**DIGITAL MEMORIES & PROGRAMMABLE LOGIC:** ROM, RAM (static and dynamic), PROM, PLA and PAL	4
Unit 7	**LOGIC FAMILIES:** Brief overview of Transistor as a switch, Logic gate characteristics – propagation delay, speed, noise margin, fan-out and power dissipation, Standard TTL and static CMOS gates	4
Unit 8	**A/D AND D/A CONVERTERS:** Various types of A/D and D/A Converters, Performance Parameters (Resolution, Accuracy etc.)	4

List of Experiments:		Number of Turns
1	Introduction to Proteus software and HDL simulation software and front-end work flow using Xilinx Vivado software	**1**
2	Implementation of various arithmetic circuits (4-bit parallel adder, combined adder-subtractor, multiplier, BCD adder)	**2**
3	Implementation and simulation of code converters	**1**
4	Implementation and simulation of other combinational circuits like multiplexers, encoders, decoders, etc.	**2**
5	HDL implementation of various arithmetic and logical circuits	**2**
6	Implementation and simulation of synchronous sequential circuits like Flip-flops, registers and counters	**3**
7	Simulation of an application based on digital circuits and its logic synthesis using FPGA	**2**

Course Outcomes: By the end of this course, students will be able to:	
1	Apply the concepts of Boolean algebra for designing and simplifying logic circuits.
2	Design and analyze various combinational circuits like MUX, DEMUX, PLDs, etc.
3	Design and analyze various synchronous and asynchronous sequential circuits like flip-flops, counters, FSMs, etc.
4	Compare different logic families, memories and A/D and D/A converters and compare them based on their performance.
5	Implement different combinational and sequential circuits using the ICs of basic logic gates and simulate them using VHDL.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Digital Design by Morris Mano, PHI, 4th edition	2008
2	Digital principles and Applications, by Malvino Leach, TMH	2011
3	Modern Digital Electronics, by R P Jain, TMH	2009
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Digital System Principles and Applications, by R J Tocci (PHI)	2017
2	Digital Integrated Electronics, by Taub Schilling, TMH	2017
3	Digital Electronics: Principles, Devices And Applications, by A. K Maini, Wiley	2007

Sr. No.	Course Links	Offered by
1	https://onlinecourses.nptel.ac.in/noc22_ee55/preview	NPTEL
2	https://www.coursera.org/learn/digital-system	Coursera

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

Course Name	**:**	**ELECTRONIC DEVICES & CIRCUITS**
Course ID	**:**	**EXN302**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:

Students should be able-

- To explain the physics and operation of semiconductor devices such as PN junction diode, BJT and FET.
- To analyze the characteristics of these device's circuits and the use of these active devices in various configurations using different biasing techniques.
- To analyze the mathematical models of the transistor and explain the behaviour and frequency response of amplifier circuits using that model.
- To describe the working operation of other semiconductor devices.
- To demonstrate the hands-on working of active semiconductor devices using discrete components and evaluate their performance with various testing and measuring equipments.

Total No. of Lectures –42

Lecture wise breakup		**No. of Lectures**
Unit 1	**SEMICONDUCTOR PHYSICS** Electron affinity, work function, quasi-states, fermi level, Equilibrium Carrier concentration, Temperature dependence on Carrier concentration, Drift, Diffusion, Recombination-generation	6
Unit 2	**PN JUNCTION DIODE AND DIODE CIRCUITS** Space charge at a junction, electrostatic analysis of junction at different bias conditions, band diagrams, Depletion and Diffusion Capacitances, Switching Characteristics, and Breakdown Mechanisms, Rectifier circuits, Zener diode as Voltage regulators, Clippers, Clampers, Special purpose diodes, Metal-Semiconductor Junctions: Schottky barrier, Rectifying and Ohmic Contacts	8
Unit 3	**BIPOLAR JUNCTION TRANSISTORS** Transistor operation, Carrier Distribution, Transit Time, Transistor configurations, characteristics of CB, CE and CC configuration, Transistor as an amplifier, Load line and Operating point, Bias stability, various biasing circuits, Thermal Runaway, Thermal stability	5
Unit 4	**METAL OXIDE FIELD EFFECT TRANSISTORS:** Basic Operation, Ideal MOS Capacitor, Electrostatic analysis, Effects of real surfaces, Threshold Voltage, Body effect, C-V and I-V Characteristics	8
Unit 5	**AMPLIFIERS** Small-Signal Model, FET/MOSFET; Biasing and Design of FET/MOSFET (CS, CG, and CD) Amplifiers, Frequency Response of Amplifiers, High-Frequency Device Models, Gain bandwidth product	8
Unit 6	**OTHER SEMICONDUCTOR DEVICES:**	7

	Compound semiconductor-based electronic, optoelectronic, and photonic devices and integrated circuits, CCD, and imaging devices	

List of Experiments		**No. of turns**
1	To familiarize students with electronic components and various testing and measuring equipments.	2
2	To study the V-I characteristics of the p-n junction diode and determine static resistance and dynamic resistance.	2
3	To simulate and implement clipper and clamper circuits.	2
4	To simulate and implement half-wave and full-wave rectifiers.	2
5	To simulate and implement BJT in different configurations and observe the characteristics.	2
6	To simulate and implement MOSFET in different configurations and observe the characteristics.	2
7	To simulate and verify the operation of BJT/MOSFET as an amplifier and draw the frequency response.	2

Course Outcomes: By the end of this course, students will be able to:	
1	Analyze simple electronic circuits based on the knowledge of devices such as diodes and transistors (BJT and FET) with special focus on designing amplifiers with discrete components
2	Develop and analyze bias circuits for BJTs/FETs for the basic configurations.
3	Analyze the modeling of a transistor and formulate the performance parameters of the amplifier.
4	Design amplifiers and perform frequency analysis using small signal models.
5	Demonstrate basic skills using electronic device simulations, implement and analyze the same using discrete devices.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	D. A. Neamen and D. Biswas, Semiconductor Physics and Devices, 4th edition. Tata McGraw-Hill, 2012.	**2012**
2	R. F. Pierret, Semiconductor Device Fundamentals. Pearson	**2018**
3	B. Razavi, Fundamentals of Microelectronics, 2nd edition. Wiley-India, 2014.	**2014**
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**

1	B. G. Streetman and S. K. Banerjee, Solid State Electronic Devices, 7th edition. Pearson, 2015.	**2015**
2	A. S. Sedra and K. C. Smith, Microelectronic Circuits: Theory and Applications, 7th edition. Oxford, 2017.	**2017**
3	Millman & Halkias, Electronic devices and circuits, TMH	**2017**
4	Sedra, A. S., Smith, K. C., and Chandorkar, A. N., (2013), Microelectronic Circuits: International Version, 6th Edition, Oxford University Press	**2013**

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	Semiconductor Devices and Circuits By Prof. Sanjiv Sambandan Semiconductor Devices and Circuits - Course (nptel.ac.in)	NPTEL
2	Fundamentals Of Electronic Materials And Devices By Prof. Parasuraman Swaminathan Fundamentals Of Electronic Materials And Devices - Course (nptel.ac.in)	NPTEL
3	Basic Electronics and Lab, IIT Madras Prof. T.S. Natarajan NPTEL	NPTEL

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

Course Name	**:**	**PROBABILITY AND RANDOM PROCESSES**
Course ID	**:**	**EXN303**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:

Students should be able –

- To develop the fundamentals of various theorems/axioms of probability.
- To analyze various continuous and discrete-time random variables and apply this knowledge to solve diverse problems.
- To explore the inequalities like Markov, Chebyshev and Chernoff bounds, understand their applications in bounding probabilities and analyze the behaviour of random variables.
- To apply the fundamentals of probability theory and random processes for solving practical engineering problems in communication systems.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION TO PROBABILITY** Definitions of probability (Axiomatic and relative frequency), Axioms of probability, Events as sets, Conditional Probability, Independence, Concept of random variables	4
Unit 2	**DISCRETE RANDOM VARIABLES** Some examples of discrete distributions, Probability mass functions, some standard discrete probability distributions such as Bernoulli, Binomial, Poisson and Geometric, Independence, Expectation, Indicators and their usage, Conditional distributions and conditional expectations, Sum of random variables	6
Unit 3	**CONTINUOUS RANDOM VARIABLES** Some examples of continuous distributions, Probability density functions, Independence, Expectation, Conditional distributions and conditional expectations, Functions of random variables	9
Unit 4	**CONVERGENCE OF RANDOM VARIABLES AND DIFFERENT INEQUALITIES** Central limit theorem, Law of large numbers, zero-one law (Borel-Cantelli Lemma), Markov inequality, Chebyshev inequality, Jensen's Inequality	7
Unit 5	**RANDOM PROCESSES** Definition of random processes, Gaussian processes, Stationary processes, Markov Processes (MP), Classification of states in MP, Stationary distributions in MP, Bernoulli Processes, Poisson processes, Combining and splitting of Poisson processes.	12
Unit 6	**APPLICATIONS OF PROBABILITY AND RANDOM PROCESS IN COMMUNICATIONS** Self -Information and entropy, Probability of error calculation using MAP and ML Detector, characterizing wireless channel using random variables, Wireless	4

	networks and stochastic geometry, Markov state modeling of a communication channel. Case study on applications using MATLAB/Open-Source Software.	

Course Outcomes: By the end of this course, students will be able to	
1	Describe the concept of random variables and define the axioms of probability.
2	Explore different discrete and continuous random variables along with their functions and apply this knowledge to solve some practical problems.
3	Analyze the concept of convergence of random variables and comprehend the various inequalities frequently employed in probabilistic modeling.
4	Describe the concept of random processes and analyze the characteristics of different stochastic processes, including Markov, Bernoulli and Poisson processes to solve statistical problems.
5	Develop a Markov state model for a specific communication application and evaluate its effectiveness.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Probability - Random Variables and Stochastic Processes, 4th edition, by Athanasios Papoulis and S Pillai, McGraw Hill Education	2017
2	Stochastic Processes: Theory for Applications, 1st edition, by Robert G. Gallager, Cambridge University Press	2013
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Probability and Random Processes, 4th edition, by Geoffrey Grimmett (Author), David Stirzaker, OUP Oxford	2020
2	Applied Statistics and Probability for Engineers, 6th edition, by Douglas C. Montgomery (Author), George C. Runger , Wiley	2016
3	Wireless Communications, 1st edition, by Andrea Goldsmith Cambridge University Press	2005

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Probability and Random Processes by Prof. Rohit Sinha, Prof. Ribhu (IIT Guwahati), https://onlinecourses.nptel.ac.in/noc22_ee123/preview.	NPTEL
2	Probability and Random Variables/ Processes for Wireless Communications, Prof. Aditya K. Jagannatham (IIT Kanpur), https://nptel.ac.in/courses/117104117.	NPTEL

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

Course Name	**:**	**CIRCUIT THEORY**
Course ID	**:**	**EXN304**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives

Students should be able-

- To apply sinusoidal steady-state analysis techniques to AC circuits.
- To evaluate the responses of circuits in time domain and frequency domain.
- To analyze graph theory principles for electrical networks.
- To explore the synthesis of networks using elements of realizability and stability criteria.
- To design passive filters, including low-pass, high-pass, band-pass, and band-stop filters and their frequency responses.

Total No. of lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**SINUSOIDAL STEADY STATE ANALYSIS:** Sinusoids, Phasors, Impedance and admittance, Kirchhoff's law in frequency domain, impedance combinations, steady state analysis: nodal and mesh analysis, dependent, independent voltage and current sources, source transformation, Thevenin and Norton equivalent. AC power analysis: instantaneous and average power, max average power transfer, RMS value, apparent power and power factor, complex power, conservation of AC power. Three-phase circuits: types of load and source connections, power in balanced three-phase circuits, star-delta transformations. Network theorems.	8
Unit 2	**TRANSIENT NETWORK ANALYSIS:** Complex frequency and Laplace transforms, circuits analysis in S domain, poles, zeros, transfer Functions and driving point impedances and convolution, Time domain response of RL, RC & RLC Circuits.	8
Unit 3	**TWO PORT NETWORKS:** Short circuit admittance parameters, open circuit impedance parameters, hybrid and transmission parameters, series-parallel and tandem connection of two port networks, multi-port networks, multi-terminal networks, indefinite admittance matrix and its properties, relationships among different network parameters	6
Unit 4	**NETWORK SYNTHESIS** Elements of realizability theory: causality and stability, Hurwitz polynomials, positive real functions, elementary synthesis procedure, synthesis of one port network with two kinds of element: L-C driving point immittances, synthesis of R-L, L-C functions.	10
Unit 5	**GRAPH THEORY:** Introduction, Linear graph of a network, Tie-set and cut-set schedule, incidence matrix, Analysis of resistive network using cut-set and tie-set, Dual of a network.	5
Unit 6	**FILTERS:**	5

	Series and parallel resonance, single and double tuned circuits. Passive filters: low-pass, high-pass, band-pass and band-stop filters, the difference between actual and ideal frequency response.	

Course Outcomes: By the end of this course, the students will be able to	
1.	Solve simple and complex DC and AC circuits using various methods such as nodal, mesh and graph analysis.
2.	Predict the circuit response in the time domain and frequency domain using Laplace transform.
3.	Estimate the stability of a network's immittance function and verify the same from pole zero plot analysis.
4.	Design a passive electrical network from a given impedance/admittance function.
5	Examine two-port networks using various parameters and filter circuits.

Textbooks:		
Sr. No.	**Name of Book/Authors/Publisher**	**Year of Publication /Reprint**
1.	Network Analysis, M.E Van Valkenburg, PHI 3rd edition	2019
2.	Fundamentals of Electric Circuits, C K Alexander & Matthew N O Sadiku, Mc Graw Hill, 7th edition.	2022
3.	Circuit Theory Analysis and Synthesis, A. Chakrabarty, Dhanpat Rai Publishing Company (P) Limited.	2008
Reference Books:		
Sr. No.	**Name of Book/Authors/Publisher**	**Year Of Publication /Reprint**
1.	Engineering Circuit Analysis, W H Hayt, J E Kemmerly & S M Durbin, Tata McGrawHill Education	2005
2.	Sonar for Practicing Engineers (3rd edition), by A.D. Waite, Wiley Publications.	2002
3.	Fundamentals of Electric Circuit Theory, by D. Chattopadhyay, P.C Rakhshit, S.Chand (G/L) & Company Ltd	2020

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Circuit Theory, IIT Delhi, Prof. S.C. Dutta Roy https://nptel.ac.in/courses/108102042	NPTEL
2	Network Analysis, IIT Kharagpur, Prof. T.K. Bhattacharya https://nptel.ac.in/courses/108105159	NPTEL

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

Course Name	**:**	**ANALOG AND DIGITAL COMMUNICATION**
Course ID	**:**	**EXN401**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives
Students should be able- ● To explore the various functional blocks in analog and digital communication systems. ● To explain various analog modulation and demodulation techniques. ● To describe various digital modulation schemes. ● To examine different multiple access techniques. ● To explore the concepts of information theory and coding.

Total No. of Lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION TO COMMUNICATION SYSTEMS:** Principles of Communication, Signal to Noise Ratio, Channel Bandwidth, Rate of Communication, Modulation.	2
Unit 2	**AMPLITUDE MODULATION:** Baseband and carrier communication, Amplitude modulation: Double side Band (DSB), Single Side Band (SSB), Vestigial Sideband (VSB), AM Transmitter and Receiver.	7
Unit 3	**ANGLE MODULATION:** Concept of Instantaneous Frequency, Bandwidth of Angle Modulation, Generation of FM wave, Demodulation of FM, Interference of Angle Modulated Systems, FM Receivers.	7
Unit 4	**INTRODUCTION TO DIGITAL COMMUNICATION SYSTEMS:** Advantages of digital communication over analog communication, Digital communication system (description of different modules of the block diagram), Complex baseband representation of signals, Gram-Schmidt orthogonalization procedure. Channels and signals/waveforms in 5G.	5
Unit 5	**DIGITAL TRANSMISSION AND MODULATION TECHNIQUES:** Analog to digital conversion schemes: PCM, PPM, PWM, Delta Modulation, Adaptive Delta Modulation, Pulse amplitude modulation (binary and M-ary, Quadrature Amplitude Modulation (QAM)), Pulse position modulation (binary and M-ary), Carrier modulation (M-ary Amplitude Shift Keying (ASK), Phase Shift Keying (PSK), Frequency Shift Keying (FSK), Differential Phase Shift Keying (DPSK)), Continuous phase modulation (Quadrature Phase Shift Keying (QPSK) and variants.	10
Unit 6	**MULTIPLE ACCESS TECHNIQUES:** Time division, frequency division, and spatial division multiple access schemes, principles of Orthogonal Frequency Division Multiple Access (OFDMA) and Code-	5

	Division Multiple Access (CDMA). Non-Orthogonal Multiple Access (NOMA) for 5G.	
Unit 7	**INFORMATION THEORY AND CODING:** Concept of information, Entropy, Mutual information, Source encoding, Channel encoding, Channel capacity	6

List of Experiments		**No. of Turns**
1.	To implement modulation and demodulation of Double sideband modulation with carrier and double sideband modulation- suppressed carrier (DSB-SC)	2
2.	To simulate single-sideband modulation (SSB) and demodulation	1
3.	To simulate phase and frequency modulation and demodulation	2
4.	To implement modulation and demodulation of pulse amplitude modulation (PAM), pulse width modulation (PWM), and pulse position modulation (PPM)	2
5.	To implement delta modulation and adaptive delta modulation	1
6.	To simulate the modulation of amplitude shift keying (ASK), frequency shift keying (FSK)	2
7.	To implement modulation of differential phase shift keying modulation (DPSK)	2
8.	Case studies on modulation and multiplexing schemes in 5G and beyond	2

Course Outcomes: By the end of this course, the students will be able to	
1.	Explain the different analog modulation techniques.
2.	Explore various digital transmission and modulation schemes.
3.	Summarize various multiple access techniques.
4.	Evaluate the basic concepts of information theory and coding.
5.	Implement various analog and digital modulation schemes for different applications using MATLAB

Textbooks:		
Sr. No.	**Name of Book/Authors/Publisher**	**Year Of Publication /Reprint**
1.	Modern Digital & Analog Communication Systems by B.P. Lathi, Oxford University Press,4th Edition	2009
2.	Digital Communication by John G. Proakis and Masoud Salehi, Fifth edition, McGrawHill Higher education	2008
3.	Elements of Information Theory, by Thomas Cover and Joy Thomas, 2nd edition, Wiley –Interscience	2006
Reference Books:		
Sr. No.	**Name of Book/Authors/Publisher**	**Year Of Publication /Reprint**

1.	Fundamentals of Analogue and Digital Communication Systems by Sunil Bhooshan, Springer, 1st Edition	2022
2.	Electronic Communication Systems by G. Kennedy And B. Davis, Mc Graw Hill, 4th Edition	2006
3.	Principles of Communication Systems by Taub and Schilling Tata McGraw-Hill Education, 3rd edition	2008

Equivalent MOOC courses:

Sr. No.	Course Links	Offered By
1.	Analog communication by Prof. Goutam Das, IIT Kharagpur https://onlinecourses.nptel.ac.in/noc21_ee74/preview	NPTEL
2.	Digital Communication by Prof. Bikash Kumar Dey, IIT Bombay https://nptel.ac.in/courses/117101051	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	**H**	**H**	**M**						**M**				**H**	**H**
CO2	**H**	**H**	**H**						**M**				**H**	**H**
CO3	**H**	**H**	**M**						**M**				**H**	**H**
CO4	**H**	**H**	**L**						**M**				**H**	**H**
CO5	**H**	**H**	**H**		**H**				**M**	**M**			**H**	**H**

Course Name	**:**	**ANALOG ELECTRONICS**
Course ID	**:**	**EXN402**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:

Students should be able-

- To design and analyze feedback amplifiers and oscillator circuits.
- To explore the basic building blocks of operational amplifier, their functioning and demonstrate various applications of operational amplifiers.
- To analyze the working of multi-vibrators and the operating principle of phase locked loop.
- To experience the hands-on working of basic electronic circuits using discrete components and evaluate their performance with various testing and measuring equipments.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**POWER AMPLIFIERS** Class A, B, AB stages, output stages, short circuit protection, power transistors and thermal design considerations	6
Unit 2	**FEEDBACK AMPLIFIERS AND OSCILLATORS** Concept of feedback, Negative feedback and its advantages, Modification of I/O impedances, sense and Return techniques, VCCS, VCVS, CCVS, CCCS, Stability in feedback systems, Basic principles of sinusoidal oscillators, tuned collector, tuned base, Hartley oscillator, Colpitt's Oscillator, Phase Shift Oscillator, Wein Bridge Oscillator, Crystal Oscillator, Frequency stability of Oscillator.	8
Unit 3	**CURRENT MIRRORS:** Basic current mirrors, Cascode current mirrors, Active current mirrors with large and small signal analysis	6
Unit 4	**DIFFERENTIAL AMPLIFIERS** MOS differential pair's large signal analysis, small signal analysis of differential pairs, cascode differential amplifiers, common-mode rejection, and differential amplifiers with active load, frequency response of cascode and differential amplifiers	10
Unit 5	**OPERATIONAL AMPLIFIERS** Op-Amp characteristics and specifications, the concept of virtual ground, Inverting and non-inverting amplifiers, op-amp applications including voltage summer, integrator, differentiator, instrumentation amplifiers, Zero crossing detector, Schmitt trigger, Filter specifications, design of low pass, high pass, band pass and band reject filters using operational amplifiers	8
Unit 6	**MULTIVIBRATORS** 555 timer as monostable, astable and bistable multivibrator, phase-locked loop (PLL)	4

List of Experiments:		**No. of turns**
1.	To simulate feedback amplifiers and oscillator circuits.	2

2.	To Simulate and implement the working of the RC oscillator.	2
3.	To Simulate and implement the working of Opamp as a summing and difference amplifier.	1
4.	To Simulate and implement the working of Opamp as an integrator & differentiator.	1
5.	To Simulate and implement the working of active and passive low pass filters and observe the frequency response.	2
6.	To Simulate and implement the working of active and passive high pass filters and observe the frequency response.	2
7.	To Simulate and implement the working of an Astable, monostable and bistable multivibrator using a 555 timer	2
8.	Introduce different circuit and design parameters like gain, bandwidth, ICMR, CMRR, PSRR, slew rate and others through DC, AC and transient analysis using SPICE simulations	2

Course Outcomes: By the end of this course, the students will be able to	
1.	Describe and analyze feedback in amplifiers and the operation of various oscillator circuits.
2.	Analyze the working of analog circuits like differential amplifiers, current mirrors, etc. from the small signal model of the transistors.
3.	Explain operational amplifier along with its applications.
4.	Illustrate the working of various modes of multi-vibrator circuits and explain the basic principle of a phase-locked loop.
5.	Demonstrate and use circuit design software and hardware equipment to validate the functioning of analog devices and circuits and their applications.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Sedra, A. S., Smith, K. C., and Chandorkar, A. N., (2013), Microelectronic Circuits: International Version, 6th Edition, Oxford University Press	2013
2.	B. Razavi, *Fundamentals of Microelectronics*, 2nd edition. Wiley-India, 2014.	2014
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Op-amps and linear integrated circuits by Ramakant A Gayakward Prentice hall 4th edition	2000
2	Electronics Devices & Circuit Theory, RL Boylestead & L Nashelsky, PHI	2008
3	Electronics Circuit Analysis and Design, Donald A. Neamen, Tata McGraw Hill	2009
4	Millman, Halkias, Integrated Electronics, TMH	2016

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	Analog Electronic Circuits By Prof. Shanthi Pavan Analog Electronic Circuits - Course (nptel.ac.in)	NPTEL
2	ANALOG ELECTRONIC CIRCUITS, IIT Delhi Prof. S.C. Dutta Roy NPTEL	NPTEL

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

Course Name	**:**	**SIGNALS AND SYSTEMS**
Course ID	**:**	**EXN403**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:

Students should be able –

- To analyze and classify signals and systems and perform various operations on signals.
- To compute the output of a Linear Time-Invariant system through convolution.
- To apply Fourier analysis for periodic and non-periodic signals.
- To utilize Laplace transform to represent and analyze continuous LTI systems.
- To utilize Z transform to represent and analyze discrete LTI systems.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION TO SIGNALS AND SYSTEMS:** Signals and systems as seen in everyday life, signals and their classification, basic operations on signals, elementary CT/DT signals, properties and classification of systems, Systems viewed as Interconnection of Operations, Relation between continuous and discrete-time systems, Problem-Solving using MATLAB	8
Unit 2	**TIME DOMAIN REPRESENTATION OF LINEAR TIME INVARIANT SYSTEMS:** Introduction, Convolution Sum and evaluation procedure, convolution Integral and Evaluation Procedure, Interconnection of LTI procedures, Relation between LTI system properties and impulse response, System representation through differential equations and difference equations, Block Diagram Representation, State Variable Description, Problem Solving using MATLAB	11
Unit 3	**FOURIER REPRESENTATIONS OF SIGNALS:** Introduction, Complex Sinusoids and Frequency Response of LTI Systems, Fourier representation of Discrete-time and Continuous-time Periodic Signals, Fourier representation of Discrete-time and Continuous-time Nonperiodic Signals, Properties of Fourier Representations, correlation, auto-correlation and cross-correlation and their properties, energy spectral density, power spectral density, Sampling theorem, spectra of sampled signals, reconstruction, Problem-Solving using MATLAB	10
Unit 4	**REPRESENTING SIGNALS BY USING CONTINUOUS TIME COMPLEX EXPONENTIALS: THE LAPLACE TRANSFORM** Introduction, Unilateral and Bilateral Laplace transform, their inversion and properties, properties of the region of convergence, transfer function, causality and stability, Laplace transform methods in circuit analysis.	6
Unit 5	**REPRESENTING SIGNALS BY USING DISCRETE TIME COMPLEX**	7

	EXPONENTIALS: THE Z- TRANSFORM: Z-transform and its properties, Region of convergence and its properties, inverse Z transform, transfer function, causality and stability. Computational structure for implementing discrete-time LTI systems, Unilateral Z-Transforms.	

Course Outcomes: By the end of this course, students will be able to	
1	Analyze continuous and discrete signals and systems and solve related problems.
2	Classify systems based on their properties and determine the response of LTI system using convolution
3	Analyze the spectral characteristics of continuous time periodic and aperiodic signals using fourier analysis
4	Analyze and characterize the CT systems through Laplace Transform and investigate region of convergence.
5	Analyze and characterize the DT systems through Z-Transform, investigate RoC and develop computational structures.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Signals and Systems by A.V. Oppenheim and A.S. Willisky, 2nd edition, Pearson Education	2015
2	Signals and Systems by Simon Haykin and Barry Van Veen, 2nd edition, Wiley	2007
3	Modern Digital & Analog Communication Systems by B.P. Lathi, 4th edition, Oxford	2011
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Signals And Systems by A. Anand Kumar, 3rd edition, Prentice Hall India Learning Private Limited	2013
2	Introduction to Communication Theory by P.D. Sharma, Roorkee Nem Chand and Sons	1971
3	Circuits and Networks (Analysis and synthesis) by A. Sudhakar and Shyammohan S. Palli, 5th edition, McGraw Hill Education	2017

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Principles of Signals and Systems by Prof. Aditya K. Jagannatham (IIT Kanpur). https://onlinecourses.nptel.ac.in/noc20_ee15/preview.	NPTEL
2	Signals and Systems by Prof. Kushal K. Shah (IISER Bhopal), https://onlinecourses.nptel.ac.in/noc21_ee28/preview.	NPTEL

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

Course Name	**:**	**CONTROL SYSTEMS**
Course ID	**:**	**EXN404**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:

Students should be able-

- To develop the model of a control system using different approaches.
- To analyze the system in time domain and frequency domain and investigate its stability.
- To design Compensators and Controllers for the specified requirements.
- To analyze sampled data control systems and apply state variable approach to control systems.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION AND MODELLING OF CONTROL SYSTEMS** Basic components of a control system, classification of the control system, Servomechanism, Regulator and process control, Feedback control Systems-Characteristics and Performance, Transfer function approach, Block Diagram Representation, Signal flow graphs	6
Unit 2	**TIME RESPONSE ANALYSIS** Time response of first-order systems, second-order systems, performance specifications, steady state errors and error constants, Sensitivity	6
Unit 3	**CONCEPT OF STABILITY** Conditions of stability, Routh-Hurwitz criterion, Root locus technique	5
Unit 4	**FREQUENCY RESPONSE ANALYSIS** Correlation between time and frequency response, Polar Plots, Bode Plot, stability margins on Bode plots, Nyquist criteria, Assessment of stability using Nyquist criteria	8
Unit 5	**COMPENSATOR DESIGN USING BODE PLOTS** Preliminary considerations of classical design, realization of basic compensators, Lead compensator, Lag compensator, Lag-Lead Compensator, Introduction to Computer-aided design using MATLAB	6
Unit 6	**CONTROL ACTIONS AND CONTROLLER CHARACTERISTICS** Proportional, Integral and Derivative Control Actions, Proportional plus integral control action, proportional plus derivative control action, PID controller	3
Unit 7	**DIGITAL CONTROL SYSTEMS** Introduction, Z-transform analysis of sampled data control systems, Z and s-domain relationship, stability analysis	4
Unit 8	**STATE VARIABLE ANALYSIS OF CONTROL SYSTEMS** Concepts of state, state variables and state model, state models for linear continuous-time systems, transfer function from state model, solution of state equation, State Transition Matrix, Single Input Single output system, multiple input multiple output system, concept of controllability and observability	4

Course Outcomes: By the end of this course, the students will be able to:	
1	Determine the transfer function of the system using different approaches.
2	Compute the time domain response of first and second order systems and evaluate transient response specifications.
3	Investigate stability using Bode plots, Nyquist plots, Routh-Hurwitz criteria and Root locus.
4	Analyze Proportional, Integral and Derivative control actions along with lead and lag compensation and design compensators and PID controllers for specified requirements.
5	Develop and analyze the state space models of systems and apply z transform to analyze digital control systems.

Textbooks:		
Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Control Systems Engineering By Nagrath and Gopal, New Age International,4th Ed	2021
2	Digital Control Engineering by M Gopal, New Age International	2014
3	Control Systems Engineering, Nise, N. S., 6th Ed., Wiley India	2017
Reference Books:		
Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Modern Control Engineering, Ogata, K., 5th Ed., Pearson Education. 2008	2015
2	Modern Control Systems, Dorf, R.C. and Bishop, R.H., 12th Ed., Prentice-Hall of India.	2016
3	Automatic Control Systems, Kuo, B.C, 9th Ed., Wiley India	2014

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Course Name: Systems and Control https://ocw.mit.edu/courses/2-04a-systems-and-controls-spring-2013/	MIT Open courseware
2	Course Name: Control Systems https://onlinecourses.nptel.ac.in/noc19_de04/preview	NPTEL

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

Course Name	**:**	**CMOS Digital VLSI Design** *(Pre-requisites: Digital Logic Design and Electronic devices and circuits)*
Course ID	**:**	**EXN405**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:

Students should be able -

- To explain the scaling effects and short channel effects for MOSFET
- To analyze the static and dynamic power dissipation in CMOS circuits
- To design combinational and sequential CMOS circuits
- To describe the effect of interconnects on crosstalk and delay
- Explain different types of semiconductor memories

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**MOSFET SCALING AND ITS EFFECTS:** MOSFET Short Channel Effects, Geometric Scaling Theory and its effects– Full- Voltage Scaling, Constant Voltage Scaling.	4
Unit 2	**DESIGN FLOW AND CMOS INTEGRATED CIRCUITS LAYOUT:** Introduction to ASIC and SoC, Overview of ASIC flow, functional verification, RTL-GATE level synthesis, synthesis optimization techniques, pre-layout timing verification, static timing analysis, floor-planning, placement and routing, extraction, post-layout timing verification, extraction. CMOS Process flow, Stick Diagram and Layout – MOSFET Dimensions, Design Rules, Latch-up.	7
Unit 3	**CMOS INVERTERS:** CMOS Inverter, switching threshold and noise margin and their evaluation, static and dynamic behavior, switching characteristics- delay time calculation, static and dynamic power dissipation, techniques to reduce the power dissipation, energy and energy-delay calculations, Interconnects: Resistance, Capacitance and inductance Estimation, Delay and crosstalk	10
Unit 4	**CMOS COMBINATIONAL LOGIC GATES:** Complementary CMOS, Ratioed logic, Pass Transistors logic, Transmission Gate, CVSL, Dynamic logic: basic principle, Speed and Power Dissipation of Dynamic Logic, Issues in Dynamic Design, Cascading Dynamic Gates, NORA-CMOS-A Logic Style for Pipelined Structures	8
Unit 5	**SEQUENTIAL MOS LOGIC CIRCUITS:** Behavior of Bistable Elements, SR latch circuits, Clocked latch and Flip-flop Circuits, CMOS D-latch and Edge triggered FF, Dynamic Transmission-Gate Edge- triggered Registers. Clocks skew.	8
Unit 6	**SEMICONDUCTOR MEMORIES:** Non-volatile and volatile memory devices, flash memories, SRAM Cell Design, Differential Sense Amplifiers, DRAM Design, Memory peripheral circuitry, power dissipation in memories	5
Unit 7	**CASE STUDY:** Static timing analysis from cadence e-learning resources	

List of Experiments:		No. of Turns
1	Familiarization with simulation software for schematic, layout entry and circuit simulation	2
2	Perform the DC analysis of an n-channel MOSFET with W/L = 1.4µm/ 0.35µm at 180 nm technology node and plot its transfer characteristics and output characteristics.	2
3	Design a symmetric CMOS inverter with a load capacitance of 1 pF: a. Perform its transient analysis. b. Calculate and verify the rise time, fall time and propagation delay.	2
4	Design a symmetric CMOS inverter having W/L=1µm/ 0.18µm: a. Draw its layout b. Perform the post-layout simulations and compare them with the schematic for C_L= 2 pF	2
5	Design and verify a 2-input CMOS NAND and NOR gates that can drive a load capacitance of 1pF. Calculate and verify it's rise time, fall time and propagation delay.	2
6	Design and plot the characteristics of a positive and negative SR latch	1
7	Design and plot the characteristics of a positive and negative edge-triggered register	1
8	Design a 6T SRAM cell and perform its read-and-write operation	2

Course Outcomes: By the end of this course, the students will be able to	
1	Describe the scaling effects on MOS devices.
2	Analyze the static and dynamic power dissipation in CMOS circuits.
3	Identify the characteristics of CMOS circuits and design combinational and sequential circuits.
4	Classify the various semiconductor memories and analyze the delay and noise effect of interconnects.
5	Design and analyze the layout and schematics of various digital VLSI circuits using CAD tools.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Digital Integrated Circuits – A Design Perspective, J.M. Rabaey, A.P. Chandrakasen and B. Nikolic, Pearson Education 2nd ed.	Latest edition
2	CMOS Digital Integrated Circuits – Analysis and Design, S. Kang and Y. Leblebici, Tata McGraw Hill 3rd ed.	2008
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	CMOS VLSI Design: A Circuits and Systems Perspective, N.H.E. Weste and K. Eshraghian, Addision Wesley 2nd ed.	1998
2	CMOS Circuit Design, Layout and Simulation, R.J. Baker, H. W. Lee, and D. E. Boyce, Wiley - IEEE Press 2nd ed	2004

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	CMOS Digital VLSI Design by Prof. Sudeb Dasgupta, IIT Roorkee https://archive.nptel.ac.in/courses/108/107/108107129/	NPTEL

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

Course Name	**:**	**MICROPROCESSORS AND MICROCONTROLLERS**
Course ID	**:**	**EXN406**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:

Students should be able –

- To analyze the architecture and operation of typical microprocessors and microcontrollers.
- To explore the programming of various microprocessor and microcontroller chips
- To interface microprocessors and microcontrollers with external devices.
- To develop a strong foundation for designing real-world applications using microprocessors and microcontrollers.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**BASIC PROCESSORS** Overview of microcomputer systems and their building blocks, memory interfacing, concepts of interrupts and Direct Memory Access, and instruction sets of microprocessors (with examples of 8085 and 8086).	8
Unit 2	**MICROPROCESSORS AND INTERFACING** Interfacing with peripherals - timer, serial I/O, parallel I/O, A/D and D/A converters; Arithmetic Coprocessors; System-level interfacing design; Concepts of virtual memory, Cache memory, Advanced coprocessor Architectures- 286, 486, Pentium.	8
Unit 3	**8051 MICROCONTROLLERS ARCHITECTURE AND INSTRUCTION SETS** 8051 Micro-controllers Architecture, Pin configuration, SFRs, Memory, 8051 Addressing modes, 8051 assembly language programming, BCD and ASCII Application Programs, 8051 Programming in C: Data Types and time delay in 8051 C, I/O Programming, Logic operations, Data conversion Programs.	10
Unit 4	**8051 MICROCONTROLLER PROGRAMMING AND INTERFACING** I/O port programming, Timers and Interrupts, LCD & Keyboard Interfacing, serial communications Programming, etc.	8
Unit 5	**ARM PROCESSOR & ITS INTERFACES** Introduction to RISC processors, ARM microcontrollers and their interface designs, an overview of Multicore processors.	8

List of Experiments:		**No. of Turns**
1	Introduction to Microsoft Macro Assemble (MASM)	**1**
2	Write 8086 ALP for the following: i.8-bit, 16-bit addition, subtraction, multiplication, division. ii. Searching the Largest & Smallest number in an array.	**2**

3	Write 8086 ALP for the following: i. Sorting in Ascending & Descending Order. ii. Block Transfer of Data	**2**
4	Write a program to move a string of data words from offset 2000H to offset 3000H the length of the string is 0FH	**2**
5	Write an ALP to Add the contents of memory location 2000H:5000H to contents of 3000H:0600H and store the result in 5000H:0700H	**1**
6	Write an ALP to arrange a given series of hexadecimal bytes in ascending order	**1**
7	Parallel Communication between Two Microprocessors using 8255	**2**
8	Interfacing LCD to 8051	**2**
9	Interfacing Matrix keyboard to 8051	**1**
10	ARM Microcontroller's basic programs.	**2**

Course Outcomes: By the end of this course, students will be able to	
1	Apply the basic concept of digital fundamentals to microprocessor and microcontroller-based personal computer systems.
2	Explain the detailed architecture of microprocessor and microcontroller.
3	Illustrate how the different peripherals are interfaced with 8086 microprocessor and 8051 microcontroller.
4	Analyze data transfer through serial & parallel ports.
5	Develop assembly language programming to design microprocessor/microcontroller based-systems.

Textbook:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Advanced Microprocessors and Peripherals by A. K. Ray and K.M. Bhurchandani, MHE, 2nd Edition, 2006.	**Latest edition**
2	The 8051 Microcontroller, Kenneth. J. Ayala, Cengage Learning, 3rd Ed.	**Latest edition**
3	R. S. Gaonkar, Microprocessor Architecture: Programming and Applications with the 8085/8080A, Penram International Publishing, 1996	**Latest edition**
4	D A Patterson and J H Hennessy, "Computer Organization and Design The hardware and software interface. Morgan Kaufman Publishers.	**Latest edition**
5	Douglas Hall, Microprocessors Interfacing, Tata McGraw Hill, 1991.	**Latest edition**

Reference Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	M.A. Mazidi & J.C. Mazidi Microcontroller and Embedded systems using Assembly & C. (2/e), Pearson Education, 2007.	Latest edition
2	The x86 Microprocessors: 8086 to Pentium, Multicores, Atom and the 8051 Microcontroller: Architecture, Programming and Interfacing by Lyla B Das, Person, 2014.	Latest edition
3	Microprocessors and Interfacing, D. V. Hall, MGH, 2nd Edition2006	Latest edition
4	The 8051Microcontrollers, Architecture and Programming and Applications - K.Uma Rao, Andhe Pallavi, Pearson, 2009.	Latest edition

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	Microprocessors and Interfacing https://archive.nptel.ac.in/noc/courses/noc20/SEM1/noc20-ee11/	NPTEL
2	Microprocessors and Microcontrollers https://archive.nptel.ac.in/courses/106/108/106108100/	NPTEL

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

Course Name	**:**	**MICROWAVE AND RADAR**
Course ID	**:**	**EXN501**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:

Students should be able-

- To analyze the characteristics of transmission lines, waveguide and mode propagation.
- To explore a wide range of waveguide components, including bends, corners, flanges, Tees, power dividers, etc.
- To explore principles related to microwave transistors, diodes, microwave sources and transferred electron devices.
- To develop a comprehensive understanding of radar principles, block diagrams, and radar operations.
- To analyze the core principles of antenna theory, including vector and scalar potentials, also explore dipoles, monopoles, patch antenna, loop antennas, etc.

Total No. of lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**BASICS OF ELECTROMAGNETIC THEORY** Sources and effects of electromagnetic fields, Electric & Magnetic Flux and Flux Density; Maxwell's Equation, Boundary conditions for electric fields and magnetic fields; Wave equation for time-harmonic fields, Solution of the wave equations, Power flow and Poynting Vector	5
Unit 2	**TRANSMISSION LINE AND WAVEGUIDE** Concept of Distributed elements, Equations of Voltage and Current, Types of Transmission lines, Standing Waves and Impedance Transformation, Lossless and Low loss Transmission lines, Power transfer on a transmission line, Transmission line calculations using Smith Chart, Applications of transmission lines, Parallel plate waveguide, Rectangular Waveguides, Field analysis and characteristics of TE and TM modes, Losses in waveguides	10
Unit 3	**MICROWAVE COMPONENTS** Scattering matrix, Attenuators and phase shifters, Bends, Corners, Twists, Flanges, Shorts, Matched loads, Tees (E-plane, H-plane & Magic), Rat-race, Directional Couplers, Power Divider- T junction, Wilkinson Power divider, Ferrite devices (isolator, circulator, gyrator). Microwave Measurement-Power and impedance measurement, Measurement of SWR, Frequency and wavelength.	7
Unit 4	**MICROWAVE SOURCES AND DETECTORS** Limitations of conventional solid-state devices at microwave frequencies, Transistors (MESFET, HEMT), Diodes (tunnel, varactor, pin), transferred electron devices (GUNN), Avalanche transit time devices (IMPATT AND TRAPATT),	7

	Limitations of conventional tubes at microwave frequencies, Klystron amplifier, Reflex klystron, Magnetron, TWT, BWO, CFA'S. Microwave detectors.	
Unit 5	**ANTENNAS FUNDAMENTALS:** The Potential Functions, Elemental Dipole Antennas (The Electric (Hertzian) Dipole, Magnetic Dipole (Loop), monopole antennas, Antenna Characteristics, The Long Dipole and Monopole Antennas, practical antennas: patch antenna, yagi-uda antenna, log periodic antenna, spiral antenna, lens antenna, etc. The Friis Transmission Equation.	7
Unit 6	**RADAR SYSTEM** Basic principle block diagram and operation of radar, Radar range equation, Applications of radars. Doppler determination of velocity, CW radar and its limitations, FM-CW radar, Basic principle and Operation of MTI radar and pulse doppler radar, Various scanning techniques, Angle tracking system	6

List of Simulations & Experiments		**No. of Turns**
1.	Study of various Microwave Components	2
2.	Measure the Insertion loss and Isolation of a Circulator.	2
3.	Draw the V-I characteristics of Reflex Klystron.	2
4.	Plot the power output v/s frequency characteristics of a Gunn source.	2
5.	Study the radiation characteristics of the horn antenna.	2
6.	Design a Rectangular waveguide using Software.	2
7.	Plot the S-parameter and radiation characteristics of the dipole antenna.	2

Course Outcomes: By the end of this course, the students will be able to	
1.	Acquire a profound understanding of transmission line, waveguide, and mode propagation including TE & TM.
2.	Analyze different microwave component characteristics including microwave transistors, diodes, transferred electron devices, and microwave tubes.
3.	Develop an understanding of the characteristics and applications of different antenna and antenna arrays.
4.	Develop an understanding to work effectively with radar systems in various applications, including surveillance, navigation, and remote sensing.
5.	Perform the characterization of different microwave components using a microwave test bench and by using EM simulation software.

Textbooks:		
Sr. No.	**Name of Book/Authors/Publisher**	**Year of Publication /Reprint**
1.	Microwave devices and circuits (3rd Edition) by Samuel Liao, Pearson Publications.	2013

2.	Introduction to Radar systems (2nd Edition) by Merill I Skolnik, McGraw Hill Publications.	2003
3	Microwave Engineering: Theory and Techniques, 4ed, by David Pozar, Wiley India	2003
4	Antenna Theory, Analysis and Design by Balanis A Constantine. 4th edition Wiley, New York	2021
Reference Books:		
Sr. No.	**Name of Book/Authors/Publisher**	**Year of Publication /Reprint**
1.	Microwave Engineering (4^{th} edition), by Sushrut Das, Oxford University Press.	2018
2.	Microwave devices and Radar Engineering (3rd Edition) by Kulkarni, Umesh Publications.	2003
3	Foundation of Microwave Engineering (2nd Edition) by RE Collin; McGraw Hill Publications.	2001

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Microwave Theory and Techniques, IIT Bombay, Prof. Girish Kumar, https://nptel.ac.in/courses/108101112	NPTEL
2	Microwave Engineering, IIT Guwahati, Dr. Ratnajit Bhattacharjee https://nptel.ac.in/courses/108103141	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	**H**	**H**	**H**						**M**				**H**	**H**
CO2	**H**	**H**	**H**						**M**				**H**	**H**
CO3	**H**	**H**	**H**						**M**				**H**	**H**
CO4	**H**	**H**	**M**						**M**				**H**	**H**
CO5	**H**	**H**	**M**		**H**				**M**	**M**		**L**	**H**	**H**

Course Name	**:**	**COMPUTER ARCHITECTURE**
Course ID	**:**	**EXN502**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives

Students should be able-

- To explore and define the architecture and organization of basic computers.
- To explore the role of different modules like control unit, central processing unit, I/O, and memory organization of basic computers.
- To develop an understanding of various concepts/algorithms of computer arithmetic.
- To define the concept of parallel processing.

Total No. of lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**REGISTER TRANSFER AND MICRO OPERATIONS** Register Transfer Language, Register Transfer, Bus & Memory Transfer, Micro-operations, Instruction codes, Computer instructions, Timing & control, Instruction Cycles, Memory reference instruction, Input /Output & Interrupts, Complete computer description & design of a basic computer.	10
Unit 2	**CENTRAL PROCESSING UNIT** Hardwired vs. Microprogrammed control unit, Instruction sequencing. Introduction of GPU. General register organization, Stack organization, Instruction format, Data transfer & manipulation, Program control, RISC, CISC.	12
Unit 3	**COMPUTER ARITHMETIC** Addition & subtraction, Multiplication Algorithms, and Division algorithms.	6
Unit 4	**I/O AND MEMORY ORGANIZATION** Peripheral devices, I/O interface, Data transfer schemes, Program control, Interrupt, DMA transfer, I/O processor. Memory hierarchy, Processor vs. memory speed, Hard disk drive, High-speed memories, Cache memory, Associative memory, Interleave, Virtual memory, and Memory management.	10
Unit 5	**PARALLEL PROCESSING** Types of parallel processors, performance considerations, pipeline processors, array processors, multicore systems, and multiprocessors.	4

Course Outcomes: By the end of this course, the students will be able to	
1.	Define the syntax of Register Transfer Language and different micro-operations.
2.	Design and construct the instruction format & addressing modes for a given operation and algorithms for addition, subtraction, multiplication & division.
3.	Explain the interdependence of different modules like the control unit, CPU and I/O interface and their design aspects.
4.	Summarize the working of different types of memories like associate memory, cache memory, virtual memory, etc. and their mapping techniques.

5.	Outline the concept of pipelining and multiprocessors.

Textbooks:		
Sr. No.	**Name of Book/Authors/Publisher**	**Year Of Publication /Reprint**
1.	Computer System Architecture, Morris M. Mano, Prentice Hall, 3rd ed.	1992
2.	Computer Architecture and Organization, J.P. Hayes, McGraw Hill, 3rd ed.	1998
3.	Computer Architecture: A Quantitative Approach, J.L. Hennessy, D.A. Patterson and D. Goldber, Pearson Education Asia, 5th ed.	2006
Reference Books:		
Sr. No.	**Name of Book/Authors/Publisher**	**Year Of Publication /Reprint**
1.	Computer Organization, C. Hamacher, Z. Vranesic, S. Zaky, McGraw Hill Education, 6th ed.	2011
2.	Computer Organization and Architecture: Designing for Performance, W. Stallings, Pearson, 8th ed.	2010
3.	Computer Organization and Design, D. A. Patterson, J. L. Hennessy, Morgan Kaufmann series, 4th ed.	2010
4.	System Architecture: software and hardware concepts, W.E. Leigh, and D.L. Ali, South Wester Publishing Co.	2000

Equivalent MOOC courses:

Sr. No.	**Course Links**	**Offered By**
1.	Computer architecture and organization by Prof. Indranil Sengupta, Prof. Kamalika Datta, IIT Kharagpur https://nptel.ac.in/courses/106105163	NPTEL
2.	Computer Architecture by Prof. Smruti Ranjan Sarangi, IIT Delhi https://onlinecourses.nptel.ac.in/noc23_cs67/preview	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	**H**	**M**	**M**						**H**				**H**	**H**
CO2	**H**	**H**	**M**						**H**				**H**	**H**
CO3	**H**	**H**	**L**						**H**				**H**	**H**
CO4	**H**	**H**	**L**						**H**				**H**	**H**
CO5	**H**	**H**	**L**						**H**				**H**	**H**

Course Name	**:**	**DIGITAL SIGNAL PROCESSING** *(Pre-requisite: Signals and systems)*
Course ID	**:**	**EXN503**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:

Students should be able –

- To analyze discrete signals and systems effectively, apply understanding of sampling, quantization, and reconstruction processes in real-world applications.
- To explore advanced techniques in DFT for applications like image and audio processing.
- To represent the discrete time systems in frequency domain.
- To develop skills in designing both Infinite Impulse Response (IIR) and Finite Impulse Response (FIR) filters.
- To apply the knowledge of multi-rate systems in real-world applications.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION** Review of discrete signals and systems analysis, sampling, quantization and reconstruction processes, Typical applications of DSP	2
Unit 2	**TRANSFORMATION OF DISCRETE SIGNALS** Basics of DFT and IDFT, circular convolution using DFT, Fast Fourier Transform (FFT), Decimation in time and decimation in frequency algorithms, IFFT, K L transform, DCT, JPEG and MPEG coding standards, Applications of DFT in speech and audio coding	12
Unit 3	**DIGITAL FILTERS** Recursive and non-recursive systems, Frequency domain representation of discrete-time systems, systems function, Ideal low pass filter	3
Unit 4	**DESIGN OF IIR FILTERS** Impulse invariance transformation technique, Bilinear transformation, Design of IIR Filters using Butterworth, Chebyshev and elliptic filter, Digital frequency transformation	5
Unit 5	**DESIGN OF FIR FILTERS** Design of FIR filters using Window technique, frequency sampling technique, Equiripple Approx. technique, comparison of IIR and FIR filters, Adaptive Weiner Filter: Adaptive Weiner filter & its application in echo cancellation and equalization	8
Unit 6	**REALIZATION OF DIGITAL SYSTEMS** Block diagrams and signal flow graphs for FIR and IIR systems, Direct form, cascade and parallel form realization of FIR and IIR systems.	4
Unit 7	**MULTIRATE DSP & APPLICATIONS** Fundamentals of Multirate systems and their applications, Decimation, Interpolation, Sampling Rate Conversion, filter banks, introduction to wavelet transform	8

List of Experiments:		No. of Turns
1	Hands-on Experience on MATLAB/Open-source software and generation of digital signals	2
2	Write a Program for Discrete Convolution, Impulse Response of finite and infinite signals	1
3	Determine and plot the Fourier Transform (magnitude and phase) for the infinite duration sequence.	1
4	Compute DFT and IDFT for the given signal.	1
5	Compute the DCT of any given signal.	1
6	Determine impulse response and unit step response of the given system.	1
7	Determine and plot the frequency response of any LTI system.	1
8	Determine the DTFT of the given sequence and plot the magnitude and phase response.	1
9	Design an FIR low pass filter for the given specifications and plot the frequency response of the filter.	1
10	Design an LP Butterworth filter for the given specifications and plot frequency response of the filter.	1
11	Write a program to obtain decimated and interpolated output of any given input signal	1
12	Compute FFT of a real-time speech and audio signal	2

Course Outcomes: By the end of this course, the students will be able to	
1	Review discrete signal processing fundamentals, including sampling and quantization processes, and understand typical applications of DSP in various fields.
2	Define the basics of DFT and IDFT, understand FFT algorithms and their applications and apply DCT in image and audio compression standards.
3	Describe recursive and non-recursive systems, analyze digital frequency transformations, and compare IIR and FIR filters.
4	Design and analyze different realizations of FIR and IIR systems using block diagrams and signal flow graphs.
5	Implement and compute the responses of various digital systems using MATLAB/Open-Source Software.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Digital Signal Processing: Principles, Algorithms, 4th Edition by J.G. Proakis and D.G. Manolakis, Pearson Education India	2007
2	Digital Signal Processing by A. V. Oppenheim and R. W. Schafer, Pearson Education	2006
3	Digital Signal Processing 4th edition by S. Salivahanan, A. Vallavraj and C. Gyanapriya, McGraw Hill	2019

Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Digital Signal Processing: A Computer-Based Approach, 4th edition, by S.K. Mitra, McGraw Hill Education	2013
2	Multirate Systems and Filter Banks by P.P. Vaidyanathan, Pearson Education	2003
3	Digital Signal Processing: A Practical Approach by Barrie Jervis (Author), Emmanuel Ifeachor, 2nd edition, Pearson	2001

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Digital Signal Processing by Prof. S.C. Dutta Roy (IIT Delhi). https://nptel.ac.in/courses/117102060.	NPTEL
2	Digital Signal Processing by C. S. Ramalingam (IIT Madras). https://nptel.ac.in/courses/108106151.	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	**H**	**M**	**M**	**L**					**M**				**H**	**H**
CO2	**H**	**L**	**H**	**H**					**M**				**H**	**H**
CO3	**H**	**M**	**H**	**M**					**M**				**H**	**H**
CO4	**H**	**H**	**H**	**M**					**M**				**H**	**H**
CO5	**H**	**M**	**M**	**H**	**H**				**M**	**M**			**H**	**H**

Course Name	**:**	**MOBILE COMMUNICATION**
Course ID	**:**	**EXN504**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:

Students should be able-

- To explore the evolution of mobile communication standards developed over the years.
- To explain path loss, shadowing and fading phenomena in wireless communication systems.
- To explore the 5G techniques e.g., massive MIMO, mmWave, V2X communications, etc. for the design of communication systems.
- To develop a basic understanding of the key technologies and enablers of 6G.

Total No. of lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**CELLULAR CONCEPTS:** Cell structure, frequency reuse, cell splitting, channel assignment, handoff, interference, capacity, power control; Wireless Standards: Overview of 2G, 2.5G, 3G, 4G and 5G cellular mobile standards and interfaces.	6
Unit 2	**PATH LOSS AND MULTIPATH CHANNEL MODELS:** Radio Wave Propagation, Free-space path loss and path loss models, Shadow Fading, and Log-normal model for shadowing. Small-Scale Multipath Propagation, Doppler Shift, Impulse Response Model of a Multipath Channel, Time Dispersion Parameters and Coherence Bandwidth, Doppler Spread and Coherence Time, Flat fading, Frequency Selective Fading, Fast Fading, Slow Fading, Rayleigh and Ricean Distributions.	10
Unit 3	**INTRODUCTION TO 5G COMMUNICATION:** 5G potential and applications, Usage scenarios, enhanced mobile broadband (eMBB), ultra-reliable low latency communications (URLLC), massive machine type communications (MMTC), D2D communications, V2X communications, Spectrum for 5G, spectrum access/sharing, millimeter Wave communication, channels and signals/waveforms in 5G, carrier aggregation, small cells, dual connectivity.	10
Unit 4	**5G NETWORK:** New Radio (NR), Standalone and non-standalone mode, non-orthogonal multiple access (NOMA), massive MIMO, beam formation, PHY API Specification, flexible frame structure, Service Data Adaptation Protocol (SDAP), centralized RAN, open RAN, multi-access edge computing (MEC); Introduction to software	10

	defined networking (SDN), network function virtualization (NFV), network slicing; restful API for service-based interface, private networks. Overview of Virtualization in cloud computing.	
Unit 5	**6G KEY ENABLERS:** 5G penetration in developed countries, 5G deployment challenges in low-middle income countries, and stronger backhaul requirements. Wireless energy harvesting, visible light communication, intelligent reflecting surface (IRS), extremely large aperture massive MIMO.	6

List of Simulations & Experiments		**No. of Turns**
1.	Study of Log-normal distribution model using MATLAB	2
2.	Simulation of Rayleigh and Ricean fading models using MATLAB	2
3.	Visualize effects of frequency-selective fading using MATLAB	2
4.	Analyse throughput and delay of a network using NetSim	2
5.	Configure an Adhoc network and study its performance using NetSim	2
6.	Simulate and study the 5G Handover procedure using NetSim	2
7.	Analyze the effect of channel allocation to primary and secondary users on throughput using NetSim	2

Course Outcomes: By the end of this course, the students will be able to	
1.	Explain the fundamental concepts and evolution of mobile communication systems.
2.	Explain 5G and beyond key-enabling technologies e.g. small cells, massive MIMO, mmWave, etc.
3.	Assess how network function virtualization helps in scalability and ease of operations.
4.	Develop an understanding of 6G key enabling technologies.
5.	Design models and implement different techniques used in mobile communications using MATLAB and NetSim.

Textbooks:		
Sr. No.	**Name of Book/Authors/Publisher**	**Year Of Publication /Reprint**
1.	Wireless communication, Principles and Practice, T.S Rappaport. 2nd Edition, Pearson	2010
2.	Wireless communications, Andrea Goldsmith, 1st edition, Cambridge University press	2009

3.	5G NR: Architecture, Technology, Implementation, and Operation of 3GPP New Radio Standards, Sassan Ahmadi, Academic Press	2019
4.	Towards 5G: Applications, Requirements and Candidate Technologies, R. Vannithamby and S. Talwar, John Wiley & Sons, West Sussex.	2017
Reference Books:		
Sr. No.	**Name of Book/Authors/Publisher**	**Year Of Publication /Reprint**
1.	Foundations of User-Centric Cell-Free Massive MIMO, Özlem Tugfe Demir, Emil Björnson and Luca Sanguinetti, Foundations and Trends® in Signal Processing, Now publishers	2021
2.	5G NR: The Next Generation Wireless Access Technology, Erik Dahlman, Stefan Parkvall and Johan Skold, Academic Press	2018
3.	Millimeter Wave Wireless Communication, T. S. Rappaport, R. W. Heath Jr., R. C. Daniels, and J. M. Murdock, Pearson Education.	2015
4.	The Architectural and Technological Revolution of 5G, José Luiz Frauendorf, Érika Almeida de Souza, Springer	2023

Equivalent MOOC courses:

Sr. No.	**Course Links**	**Offered By**
1.	Introduction to Wireless and Cellular Communications by Prof. R. David Koilpillai, IIT Madras https://onlinecourses.nptel.ac.in/noc21_ee66/preview	NPTEL
2.	Wireless Communication by Prof. Ranjan Bose, IIT Delhi https://archive.nptel.ac.in/courses/117/102/117102062/	NPTEL
3.	Evolution Of Air Interface Towards 5G by Prof. Suvra Sekhar Das, IIT Kharagpur https://nptel.ac.in/courses/108105134	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	**H**	**H**	**L**	**L**					**M**				**H**	**M**
CO2	**H**	**H**	**M**	**M**					**M**				**H**	**H**
CO3	**H**	**M**	**M**						**M**				**H**	**H**
CO4	**H**	**H**	**M**						**M**				**H**	**H**
CO5	**H**	**H**	**H**	**M**	**H**				**M**	**M**			**H**	**H**

Departmental Elective Courses-I

Course Name	**:**	**COMPUTER NETWORKS**
Course ID	**:**	**ECE105**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:

Students should be able-

- To analyze the concepts of data communication and networks in the real world.
- To explore the various layers of the OSI Model and their functionalities.
- To apply channel allocation, framing, error, and flow control techniques.
- To develop network architecture, assign IP addressing and apply various routing algorithms to find the shortest paths for network-layer packet delivery.
- To analyze the computer network infrastructure and study various security mechanisms in real-world applications.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**OVERVIEW OF DATA COMMUNICATION AND NETWORKING** Data communications, Networks, The Internet, Protocols and standards, Layered tasks, OSI model, TCP /IP protocol Architecture, History of the computer network, Internetworking Devices, an overview of SS7, Diameter and Sigtran protocols	3
Unit 2	**PHYSICAL LAYER** Data rate limit, Transmission impairments, Line coding, Block coding, Sampling, Transmission mode, Modulation of digital data, Telephone modems, Modulation of analog signal, FDM, WDM, TDM, Guided media, Unguided media	5
Unit 3	**DATA LINK LAYER** Types of errors, Detection, Error correction, Flow and error control, Stop and wait ARQ, go back n ARQ, Selective repeat ARQ, HDLC, point-to-point protocol, PPP stack, Random access (ALOHA, CSMA), Controlled access (Reservation, Polling, Token Passing), Channelization (FDMA, TDMA, CDMA), Traditional Ethernet, Fast Ethernet, Gigabit Ethernet	8
Unit 4	**NETWORK LAYER** Repeaters, Bridges, Type of Bridges, Routers, Routing concepts, Gateways, Internetworks, ARP, IP, ICMP, IPV6, Unicast routing, Unicast routing protocol, Multicast routing, Multicast routing protocols, introduction to Security, Cryptography, and SSL, Security - firewalls, DoS, etc.	6
Unit 5	**TRANSPORT LAYER** Process to process delivery, User datagram protocol (UDP), Multiplexing and Demultiplexing, Connection less transport (UDP), Principles of reliable data transfer, Transmission control protocol (TCP), Data traffic, Congestion, Congestion control, Quality of service	4
Unit 6	**PRESENTATION LAYER AND SESSION LAYER** Session layer function, Token Management, and Session Layer Protocols, Presentation layer function and Protocols	4

Unit 7	**APPLICATION LAYER** DNS, Electronics mail architecture and services, message formats and transfers, WWW architectural overview, static and dynamic web pages, HTTP, Digital audio and video	4
Unit 8	**WIRELESS NETWORKS AND SWITCHING** Cordless system, WiMAX and IEEE 802.16 broadband wireless access standards, Mobile IP, Wireless Application Protocol, IEEE 802 Architecture, IEEE 802.11 Architecture and Services, IEEE 802.11 Medium Access Control, IEEE 802.11 Physical Layer, Other IEEE 802.11 Standards, Wi-Fi Protocol Access, Bluetooth and IEEE 802.15, LTE. Emerging Applications: NFC, RFID, VoIP, SIP, video over P2P, VolTE Switching: Circuit Switching, Space division switching, Time division switching, Space and time division switching combinations, Packet switching, Data gram approach, Virtual circuit approach, message switching.	8

List of Experiments:		**Number of Turns**
1	Familiarization with networking components and devices LAN adapter, Hub, Switches, Routers, etc.	1
2	Plot the characteristic curve of throughput versus offered traffic for a Pure and Slotted Aloha system	2
3	Examine the working of ARP and IP Forwarding within a LAN and across the router	2
4	To create a scenario and study the performance of token bus and token ring protocols through simulation	2
5	Examine the working of the TCP congestion control algorithm, simulate, and plot the TCP congestion window	2
6	Wireless LAN protocols. To create a scenario and study the performance of the network with the CSMA/CA protocol	1
7	Simulate and study the stop-and-wait protocol	1
8	Simulate and study of Go Back N and Selective Repeat protocols	1
9	Simulate and study the Distance Vector Routing algorithm	1
10	Wi-Fi: Simulate and examine the throughput variation with distance	1

Course Outcomes: By the end of this course, the students will be able to	
1	Describe the computer network system and its communication.
2	Classify and compare the various layers of a computer network model, understand their role and characteristics.
3	Apply the concepts of channel allocation, framing, error, and flow control techniques.
4	Analyze the various wireless network models.
5	Implement various protocols (using NetSim software) and prepare a comprehensive case study of the computer network infrastructure.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Data Communication & Networking by Behrouz A. Forouzan, 6th edition, McGraw Hill	2022
2	Computer Networking: A Top-Down Approach by James F. Kurose and Keth W. Ross, 8th edition, Pearson Education	2022
3	Computer Networks by Andrew S. Tanenbaum, Nick Feamster and David J. Wetherall, 6th edition, Pearson Education	2022
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Computer Networks: A Systems Approach by Larry L. Peterson and Bruce S. Davie, 6th edition, Elsevier Science	2021
2	Data and Computer Communications by William Stallings, 10th edition, Pearson Education	2017
3	Data Communication and Distributed Networks by Ulylers D. Black, 3rd edition, Prentice Hall India Learning Private Limited	1994

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Computer Networks and Internet Protocol by Prof. Soumya Kanti Ghosh Prof. Sandip Chakraborty (IIT Kharagpur) https://onlinecourses.nptel.ac.in/noc21_cs18/preview	NPTEL
2	Computer Networking by Nick Feamster **(**Georgia Institute of Technology**)**. https://www.my-mooc.com/en/mooc/computer-networking--ud436/	Udacity

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

Course Name	**:**	**SEMICONDUCTOR MATERIAL SYNTHESIS AND CHARACTERIZATION**
Course ID	**:**	**ECE106**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:

Students should be able-

- To explore various material synthesis and characterization techniques.
- To utilize nano-materials for various applications.
- To explore compound semiconductor materials and associated applications.
- To have hands-on experience in material synthesis and characterization tools.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION:** Structure of solids: Introduction to engineering materials, Description of materials science tetrahedron, Force - interatomic distance curve, Structure - description of unit cell and space lattices, Coordination number, Miller indices, non-crystalline structures properties of crystalline and amorphous structures, Crystal imperfections.	8
Unit 2	**MATERIAL SYNTHESIS:** Top-down and bottom-up approaches - physical nanofabrication techniques (PVD, MBE, CVD, self-assembly, lithographic techniques, etc.) and wet chemical methods for the synthesis of zero-dimensional, one-dimensional and two-dimensional nanostructures-metal nanoparticles, quantum dots, nanoclusters, nanowires and rods, thin films	10
Unit 3	**COMPOUND SEMICONDUCTORS:** Materials properties: Merits of III –V binary and ternary compound semiconductors (GaAs, InP, InGaAs, AlGaAs, SiC, GaN, etc.), different SiC structures, silicon-germanium alloys and silicon carbide for high-speed devices, as compared to silicon-based devices, the outline of the crystal structure, dopants and electrical properties such as carrier mobility	8
Unit 4	**ELECTRON MICROSCOPY** Scanning electron microscopy (SEM), Instrumentation, Electron beam-specimen interaction, Specimen preparation, Transmission electron microscopy (TEM) - Basics of TEM, Electron sources, Specimen preparation, Image modes, Image contrast. Scanning Probe Microscopies: Scanning tunneling microscope (STM) and Atomic force microscope (AFM) - Working principles, working modes, Image artifacts	10
Unit 5	**APPLICATION OF NANOMATERIALS:** Nanomaterials in healthcare, biosensors, coatings environment, catalysis, agriculture, automotive, sensors, electronics, photonics, information technology, quantum computing, energy and aerospace sectors	6

List of Experiments:		Number of Turns
1	Synthesis of materials using sol-gel technique.	2
2	Thin film depositions using CVD, PECVD and ebeam evaporation	3
3	Synthesis of Piezoelectric materials	3
4	Material Characterization from XRD	3
5	Material Characterization from Scanning Electron Microscope	3

Course Outcomes: By the end of this course, the students will be able to	
1	Analyze the different concepts of material synthesis through various methods.
2	Develop and use the electrical and material characterization tools.
3	Explain the principles and applications of compound semiconductors.
4	Design nano-materials for various applications including healthcare, agriculture, etc.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Plummer, Deal, Griffin "Silicon VLSI Technology: Fundamentals, Practice & Modelling" PH, 2001.	2001
2	W.D. Callister, D.G. Rethwisch, Materials science and Engineering: An Introduction, 8th ed., Wiley, 2010.	2010
Reference Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	S. Zhang, Lin Li, A. Kumar, Materials Characterisation Techniques, CRC press, 2008	2008
2	Goddard III W.A., et. al., (Ed.), Handbook of Nanoscience, Engineering, and Technology, Taylor & Francis Group	2018
3	S.M. Sze (Ed), VLSI Technology, 2nd Edition, McGraw Hill.	1998
4	Relevant Research Papers	

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	https://archive.nptel.ac.in/courses/118/102/118102003 Nanotechnology	NPTEL
2	https://nptel.ac.in/courses/113106062 Fundamentals of Electronic device Fabrication	NPTEL

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

Course Name	**:**	**ANALOG AND MIXED IC DESIGN**
Course ID	**:**	**ECE107**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
Students should be able – ● To analyze the IC Process for Mixed Signal. ● To explore the basics of comparator circuits and data converters. ● To develop the understanding of amplifier design and performance challenges ● To design PLLs, DLLs and frequency synthesizers

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION:** Device Models, IC Process for Mixed Signal, Concepts of MOS Theory.	6
Unit 2	**BUILDING BLOCKS FOR CMOS AMPLIFIERS:** Design of current mirrors, differential amplifiers, CMOS operational transconductance amplifiers: design of single-ended telescopic cascode, folded cascode and two-stage amplifiers.	8
Unit 3	**FREQUENCY COMPENSATION SCHEMES:** Miller compensation, Ahuja compensation and Nested Miller compensation.	6
Unit 4	**DESIGN OF AMPLIFIERS**: Design of fully differential amplifiers, discussion of common mode feedback circuits. Switched capacitor circuits, design of switched capacitor amplifiers and integrators, the effect of opamp finite gain, bandwidth and offset, circuit techniques for reducing effects of opamp imperfections, switches and charge injection and clock feed-through effects.	8
Unit 5	**DATA CONVERTERS**: Design of sample and hold and comparators. Fundamentals of data converters; Nyquist rate A/D converters (Flash, interpolating, folding flash, SAR, and pipelined architectures); Nyquist rate D/A converters - voltage, current and charge mode converters, hybrid, and segmented converters); Oversampled A/D and D/A converters.	8
Unit 6	**PHASE LOCKED LOOP**: Design of PLLs and DLLs and frequency synthesizers.	6

Course Outcomes: By the end of this course, the students will be able to	
1	Learn the concept of MOSFET and the relationship of process technology with models used for analog IC design.
2	Design the building blocks of CMOS amplifiers.
3	Design differential amplifiers, switched capacitor-based circuits and op-amp circuits.

4	Design mixed signal VLSI blocks such as comparators, data converters and phase-locked loop.

Textbook:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Analog Integrated Circuit Design" by Tony Chan Carusone, David A. Johns, Kenneth W.Martin	2011
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	R. Gregorian and Temes - Analog MOS integrated circuits for signal processing.	2002
2	R.Gregorian - Introduction to CMOS opamps and comparators.	1999
3	B.Razavi - Monolithic Phase-locked loops and clock recovery circuits: Theory and design.	1996

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Analog IC Design https://archive.nptel.ac.in/courses/117/106/117106030/	NPTEL
2	Analog IC Design https://www.classcentral.com/course/swayam-analog-ic-design-10032	IIT Madras via swayam

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

Course Name	**:**	**NEURAL NETWORKS**
Course ID	**:**	**ECE108**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives
Students should be able- ● To explore the field of Neural Networks and relate the human neural system to the digital world. ● To explore the computational and dynamical systems using Neural Networks. ● To apply the machine and deep learning algorithms to various applications. ● To explore emerging trends and technologies in Neural Networks.

Total No. of lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**OVERVIEW OF NEURAL NETWORK:** Introduction to Artificial Neural Networks (ANN), Models of a Neuron, Network structure Error–correction learning, Feed-forward Network Functions, Single neuron/ Perceptron networks: Network Training, Gradient descent optimization, Multilayer Perceptron.	10
Unit 2	**NEURAL NETWORK-BASED RULES & ALGORITHMS:** Simple Associative Networks- Unsupervised Hebb Rule- Hebb Rule with Decay- Instar Rule-Outstar Rule- Kohonen Rule, Adaline Network- Madaline Network - Mean Square Error- LMS Algorithm- Back Propagation Neural networks – Hopfield Networks.	10
Unit 3	**INTRODUCTION TO DEEP LEARNING:** Deep generative models, Deep directed networks, Deep belief networks, Deep neural networks, Deep auto-encoders, and Applications of deep networks.	8
Unit 4	**MACHINE LEARNING:** Types of machine learning, Supervised learning, Unsupervised learning, basic concepts in machine learning, K Nearest Neighbours. Kernels, Kernel functions and Dimensionality Reduction: Subset Selection, Principal Component Analysis (PCA).	8
Unit 5	**NEURAL CONTROL APPLICATIONS:** Pattern recognition, Object recognition, Pattern classification, Supervised vs Unsupervised Classification, Natural Language Processing.	6

Course Outcomes: By the end of this course, the students will be able to:	
1.	Illustrate the fundamental areas of artificial neural networks.
2.	Acquire the knowledge of different machine learning techniques.
3.	Apply different machine-learning techniques to solve real-time problems.
4.	Model the different architectures of Neural Networks.

Textbooks:		
Sr. No.	**Name of Book/Authors/Publisher**	**Year Of Publication /Reprint**
1.	Fundamentals of Neural Networks Architectures, Algorithms, and Applications by Laurene Fausett	2004
2.	Introduction to Deep Learning: From Logical Calculus to Artificial Intelligence by Sandro Skansi, 1st Edition, Springer	2018
Reference Books		
Sr. No.	**Name of Book/Authors/Publisher**	**Year Of Publication /Reprint**
1.	Neural network design by Hagan Demuth Beale, PWS publishing company	1995
2.	Neural Networks-Algorithms, applications and programming techniques by J.A. Freeman and D.M. Skapura, Addison Wesley	1991
3.	Neural Networks - A classroom approach by Satish Kumar, Tata McGraw-Hill Publishing Company Limited	2004
4.	Machine Learning by Tom M. Mitchell, McGraw Hill Education, India	2013
5.	Research and review papers in specific area.	

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Neural Networks and Applications by Prof. Somnath Sengupta, IIT Kharagpur https://nptel.ac.in/courses/117105084	NPTEL
2	NOC: Deep Learning- Part 1 by Prof. Sudarshan Iyengar, Prof. Sanatan Sukhija, IIT Madras, https://nptel.ac.in/courses/106106184	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO 2**
CO1	**H**	**M**	**M**						**H**				**H**	**M**
CO2	**H**	**M**	**M**		**M**				**H**				**M**	**H**
CO3	**H**	**H**	**H**	**H**	**M**				**H**				**M**	**H**
CO4	**H**	**H**	**H**	**H**					**H**				**H**	**M**

Departmental Elective Courses-II

Course Name	**:**	**OPTICAL COMMUNICATION**
Course ID	**:**	**ECE109**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:

Students should be able-

- To explore the basics of optical fiber communication and use the ray and wave theory for analyzing light propagation.
- To describe the working principle and design aspects of optical transmitters and receivers.
- To explore the various causes of signal degradation in optical fiber communication.
- To explore the functioning of optical networks and explore various components used in the designing of optical fiber communication systems such as optical amplifiers and other passive components.
- To analyze theoretical results and validate those results using experimental set-ups and simulations.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**OVERVIEW OF OPTICAL FIBER COMMUNICATION:** Basic block diagram of a fiber optic communication system, advantages of optical fiber communication, basic structure of optical fiber, step-index & graded index fiber, single mode fiber, multi-mode fiber, ray theory and wave theory of light, optical fiber modes	6
Unit 2	**OPTICAL TRANSMITTERS:** Basic Concepts, Light Emitting Diodes, Semiconductor Lasers, DFB Lasers, Coupled Cavity semiconductor Lasers, Tunable Semiconductor Lasers, Vertical Cavity Semiconductor Lasers, Laser Characteristics, Transmitter design	7
Unit 3	**OPTICAL RECEIVERS:** Basic concepts, p-n Photo Diodes, p-i-n Photo Diodes, Avalanche Photodiode, MSM Photo detector, Receiver Design, Receiver Noise; Noise mechanism, Receiver sensitivity, Bit error rate, Point to point links, system considerations, link power budget, rise time budget	6
Unit 4	**OPTICAL AMPLIFIERS:** Semiconductor optical amplifier, EDFA, Raman amplifier, the principle of operation, gain and noise	4
Unit 5	**SIGNAL DEGRADATION AND NON-LINEAR EFFECTS IN OPTICAL FIBER TRANSMISSION:** Introduction, attenuation, intrinsic & extrinsic absorption losses, linear & nonlinear scattering losses, bending losses, and distortion in an optical waveguide, intramodal and intermodal dispersion. Power launching and coupling, Source-to-fiber power launching, power calculation, fiber-to-fiber joints, fiber splicing techniques, fiber connectors, OTDR, Concept	10

	of self-phase modulation, cross-phase modulation, Raman scattering, Brillouin scattering, four-wave mixing.	
Unit 6	**PASSIVE COMPONENTS OF FIBER-OPTIC NETWORKS:** Couplers/Splitters, Isolators, Circulators, Attenuators, Optical switches and wavelength converters	3
Unit 7	**OPTICAL NETWORKS:** Optical multiplexing techniques-WDM, DWDM, CWDM & CDMA, Network Topologies, operational principles of WDM - Broadcast and Select WDM networks, Single hop networks, FDDI Networks: - Frame and Token formats, Network operation, SONET/SDH, SONET frame structure, Introduction to Optical Computing & Free-space Optics, 5G and beyond.	6

List of Experiments:		**Number of Turns**
1	To calculate the numerical aperture of a single-mode fiber.	1
2	To determine the loss occurring in optical fiber link due to macro-bending.	
3	To study the length dependence of attenuation in the given optical fiber at different wavelengths.	1
4	To determine insertion loss and return loss of several connectors and return loss of PC and APC terminations.	2
5	Measurement of insertion loss and back reflection/ return loss for a series of fiber optic components (i.e. coupler, WDM, isolator, circulator, DWDM Mux/Demux devices).	2
6	Determination of isolation/ extinction ratios in various optical components.	1
7	To study and analyze analog and digital transmission of optical signals	1
8	Measurement of light, voltage and current (LVI) characteristics of a DFB laser with operating temperature.	1
9	To characterize Optical Add Drop Multiplexer in a WDM link.	1
10	To calculate the attenuation-limited fiber length based on the power budget equation.	1
11	Simulate a fiber optic system using a dispersion compensating fiber to reduce chromatic dispersion.	1
12	To perform the Eye Diagram and BER analysis of the WDM system to observe the channel crosstalk.	2

Course Outcomes: By the end of the course, students will be able to	
1	Discuss the fundamentals of optical fiber communication and apply the ray theory and wave theory of light to understand its working principle.
2	Describe the operating principle of optical transmitters and receivers and identify parameters to evaluate their performance.
3	List and describe the various impairments such as different types of losses, dispersion and non-linear phenomena occurring in optical fiber communication.

4	Explain various passive components used in optical fiber communication and analyze the use of optical amplifiers and optical networks in performance enhancement.
5	Examine the theoretical concepts and results and validate those results using experimental set-ups and simulations.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Optical Fiber Communication by Gerd Keiser, McGraw-Hill	2017
2	Fiber-Optic Communications Technology by Djafar K. Mynbaev, Lowell L. Scheiner, Pearson Education	2009
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Fiber Optic Communication Systems by G.P. Agrawal, Wiley	2010
2	Optical Networks A practical perspective by Rajiv Ramaswami, Kumar N. Sivaranjan, Elsevier	2018
3	Optical Fiber Communications, Principles and Practice, Senior, PHI	2010

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Optical-Communications- https://onlinecourses.nptel.ac.in/noc21_ee42/preview	NPTEL
2	Fiber Optic Communication Technology- https://onlinecourses.nptel.ac.in/noc20_ee79/preview	NPTEL

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

Course Name	**:**	**SEMICONDUCTOR MEMORIES**
Course ID	**:**	**ECE110**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:

Students should be able-

- To gain knowledge about different types of semiconductor memories.
- To explore architecture and operations of different semiconductor memories.
- To develop the understanding of memory design techniques and methodologies.
- To acquire hands-on experience in simulations, fabrication and characterization of memory devices.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION TO SEMICONDUCTOR MEMORY AND CMOS SCALING OVERVIEW:** Technology scaling. Static Random-Access Memories (SRAMs): SRAM Cell Structures-MOS SRAM Architecture, SRAM Technologies-Silicon On Insulator (Sol) Technology-Advanced SRAM Architectures and Technologies- Application Specific SRAMs. Dynamic Random-Access Memories (DRAMs), CMOS DRAMs-DRAMs Cell Theory and Advanced Cell Structures	8
Unit 2	**NON-VOLATILE MEMORIES:** Masked Read, only memories (ROMs): High-density ROMs, programmable read-only memories (PROMs)- bipolar PROMs, CMOS PROMs, erasable (UV)-Programmable read-only memories (EPROMs), EEPROM technology and architecture, non-volatile SRAM-Flash memories (EPROMs or EEPROM), Advanced flash memory architecture	8
Unit 3	**ADVANCE MEMORY DEVICES:** ReRAM, FeRAM, PCRAM, MRAM, Nanotube RAM, Memory cell characterization: Capacitance Voltage Characteristics, Current Voltage Characterization, Charge retention, Traps as a storage element, Endurance	10
Unit 4	**ADVANCE MEMORY DEVICES AND COMPUTING:** Multibit data storage, MIM structure for ReRAM: Types of traps and Filament formation, Resistive memory for neuromorphic computing, Brain-Inspired computing, Beyond CMOS compatibility	8
Unit 5	**MEMORY TESTING:** Memory fault modeling, testing and memory design for Testability and fault tolerance, RAM fault modeling, electrical testing, Pseudo random testing, megabit DRAM testing non-volatile memory modeling and testing	8

List of Experiments:		**No. of Turns**
1	To design and simulate SRAM cell and create its layout. Analyze the various performance parameters.	2
2	To simulate 1T-1C based DRAM cell and analyze the various performance parameters.	2

3	To deposit thin films of metals and dielectrics for the fabrication of ReRAM	4
4	To pattern the thin films of metals and dielectrics using Lithography and Etching for ReRAM	2
4	Measure the Current-Voltage Characteristics to understand the hysteresis behaviour of Memory devices	2
5	To measure the Retention and Endurance characteristics of ReRAM	2

Course Outcomes: By the end of this course, the students will be able to	
1	Analyze the designing of different types of memory cells.
2	Explore the latest developments in semiconductor memory design.
3	Perform analysis of different types of memory testing.
4	Design, fabricate and perform electrical characterization of Memory cell.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Ashok K. Sharma, Semiconductor Memories Technology, testing and reliability, Prentice Hall of India Private Limited, New Delhi 1997.	1997
2	Ashok K Sharna, Advanced Semiconductor Memories – Architecture, Design and Applications, Wiley 2002.	2002
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Nishi, Yoshio, and Blanka Magyari-Kope, eds. Advances in non-volatile memory and storage technology, Woodhead Publishing, 2019.	2019
2	MOS Device Physics and Technology, Nicolean and Brews 1982	1982
3	DIETER K. SCHRODER, Semiconductor Material and Device Characterization	2002
4	Relevant Research Papers	

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	VLSI Design https://archive.nptel.ac.in/courses/117/101/117101058/	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	**H**	**H**	**H**	**L**					**M**				**H**	**H**
CO2	**H**	**H**	**H**	**L**					**M**				**H**	**H**
CO3	**H**	**H**	**H**	**H**					**M**				**H**	**H**
CO4	**H**	**H**	**H**	**H**	**H**				**M**	**M**			**H**	**H**

Course Name	**:**	**VLSI TECHNOLOGY**
Course ID	**:**	**ECE111**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:

Students should be able-

- To develop a basic understanding of wafer processing, device fabrication techniques, device performance and intended applications.
- To explore the fundamental concepts of device integration on different substrates, as well as the benefits and drawbacks of emerging technologies.
- To acquire the basic knowledge of future trends in VLSI technology, as well as the commercialization paths for new materials, methods, and tools for VLSI devices, circuits, and systems.
- To experience hands-on introduction to fabrication of semiconductor devices.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION:** History of ICs; Operation & Models for Devices of Interest: CMOS and MEMS, Definition, Need of Clean Room, RCA cleaning of wafers, Silicon wafers; Crystallography, Production and Defects: Basic silicon wafer parameters, solid solubility of dopants in silicon, defects, and basic economics of operations.	6
Unit 2	**DIFFUSION:** Pre-Deposition and Drive-in Diffusion Modelling, Dose, 2-Step Diffusions, Successive Diffusion, Lateral Diffusion, Series Resistance, Junction Depth, Irvin's Curves, Diffusion System. **ION IMPLANTATION:** Problems in Thermal Diffusion, Advantages of Ion Implantation, Applications in ICs, Ion Implantation Systems, Mask, Energy Loss Mechanisms, Depth Profile, Range & Straggle, Lateral Straggle, Dose, Junction Depth, Ion Implantation Damage, Post Implantation Annealing, Ion Channeling, Multi Energy Implantation.	8
Unit 3	**LITHOGRAPHY:** Basic steps in lithography; lithography techniques-optical lithography, electron beam lithography, x-ray lithography, ion beam lithography; resists and mask preparation of respective lithography techniques, printing techniques-contact, proximity printing and projection printing; merits and demerits of various lithography techniques; recent trends in lithography at nanoscale	6
Unit 4	**ETCHING:** Performance metrics of etching; types of etching- wet and dry etching; dry etching techniques-ion beam or ion-milling, sputter ion plasma etching and reactive ion etching (RIE); merits and demerits of etching; etching induced defects; recent trends in etching.	6

Unit 5	**THIN FILM DEPOSITION:** Physical Vapor Deposition: Thermal evaporation, Electron beam evaporation, Laser ablation, Sputtering**,** Chemical Vapor deposition (CVD), Different kinds of CVD techniques: APCVD, LPCVD, Metal-organic CVD (MOCVD), Plasma Enhanced CVD etc., Physical vapor deposition (PVD), reaction types	8
Unit 6	**CHARACTERIZATION AND MEASUREMENT TECHNIQUES:** Optical microscope, Scanning Electron Microscope, X-ray diffraction, Atomic Force Microscopy, Secondary Ion Mass Spectroscopy (SIMS), Electrical measurement techniques, SMU, CVU, Probe Station, two-probe and four probe measurement technique	8

List of Experiments:		**Number of Turns**
1	Working in a Cleanroom environment, protocols, and wafer handling.	2
2	Thin film deposition using Thermal/ e-beam evaporation	2
3	Pattern Transfer using Optical Lithography	2
4	Wet and Dry Etching technique	3
5	Fabrication of MOS Capacitors/Schottky Diodes	3
6	Measurement of Electrical properties of MOS Capacitors/Schottky Diodes	2

Course Outcomes: By the end of this course, the students will be able to	
1	Work in the cleanroom environment for semiconductor device fabrication.
2	Recognize the basic operation principles of semiconductor fabrication equipment.
3	Analyze IC fabrication methodologies and evaluate component effects on IC design for VLSI and ULSI domains.
4	Demonstrate in-depth knowledge of Wafer preparation, Lithography and Etching, Diffusion process, Material, Device characterization and Electrical measurement techniques.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	S.M. Sze (Ed), VLSI Technology, 2nd Edition, McGraw Hill,	1988
2	Plummer, Deal, Griffin "Silicon VLSI Technology: Fundamentals, Practice & Modelling" PH.	2001
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Shubham, Kumar, Gupta, Ankaj. Integrated Circuit Fabrication, United Kingdom, Manakin Press	2021
2	DIETER K. SCHRODER, Semiconductor Material and Device Characterization	2005
3	MOS Device Physics and Technology, Nicloean and Brews	1982

4	Relevant Research Papers	

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	https://nptel.ac.in/courses/117106093 VLSI Technology	NPTEL
2	https://nptel.ac.in/courses/108101089 Fabrication of Silicon VLSI Circuits using the MOS technology, IIT Bombay	NPTEL

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

Course Name	**:**	**ADVANCED MICROPROCESSORS AND MICROCONTROLLERS**
Course ID	**:**	**ECE112**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:

Students should be able –

- To analyze the architecture and operation of typical microprocessors.
- To explore the programming and interfacing of microprocessors.
- To analyze the architecture of ARM 7 processor, LPC2148 and assembly programming of ARM.
- To design, verify and analyze ARM assembly and C language programs utilizing supporting hardware.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION TO MULTI-CORE PROCESSORS:** Single core to multi-core architectures-SIMD and MIMD systems, interconnection networks, symmetric and distributed shared memory architectures, cache coherences, performance issues, parallel program design	10
Unit 2	**ADVANCED PROCESSORS:** Introduction to Intel Architectures, Basic Components of the Intel Core 2 Duo Processor: The CPU, Memory Controller, I/O Controller; Overview of the i5 processors and the Intel Core i7 Processor	12
Unit 3	**ARM MICROPROCESSOR:** ARM Architecture, Assembly Language Programming Instruction Set, Introduction to THUMB and ARM Programming, Exception and Interrupt handling schemes, LPC2148 ARM CPU, LPC 2148 Peripherals	10
Unit 4	**AVR MICROCONTROLLER:** AVR family architecture, instruction set, hardware design issue, hardware and software interfacing, communication link for AVR processor, AVR system development tools	10

Course Outcomes: By the end of this course, the students will be able to	
1	Apply the basic concepts of digital fundamentals to Microprocessor based personal computer systems.
2	Analyze and understand the instruction set and development tools of ARM.
3	Illustrate how the different peripherals are interfaced with the ARM Microprocessor.
4	Analyze and understand the THUMB state and achieve competency in assembly programming of ARM.
5	Implement real-time applications using an AVR microcontroller.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	J.L. Antonakos, An Introduction to the Intel Family of Microprocessors, Pearson, 1999.	Latest edition
2	Barry B. Brey, The Intel Microprocessors, (7/e), Eastern Economy Edition, 2006.	Latest edition
3	Microprocessors and Interfacing, D. V. Hall, MGH, 2nd Edition, 2006.	Latest edition
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Ajay V Deshmukh, Microcontrollers (Tuning and applications), The McGraw Hill publications, 2007.	Latest edition
2	M.A. Mazidi & J.C. Mazidi Microcontroller and Embedded systems using Assembly & C. (2/e), Pearson Education, 2007.	Latest edition
3	Kenneth Hintz and Daniel Tabak, Microcontrollers architecture, Implementation and programming, TMH, 2005.	Latest edition
4	Fundamentals of Parallel Multicore Architecture by Yan Solihin, CRC Press, 2015.	Latest edition

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Microprocessors and Microcontrollers https://archive.nptel.ac.in/courses/108/105/108105102/	NPTEL
2	Start Learning Embedded Systems with AVR Atmega32 Controller https://www.udemy.com/course/embedded-systems-with-avr-microcontroller/	UDEMY

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

Departmental Elective Courses-III

Course Name	**:**	**ANTENNA THEORY**
Course ID	**:**	**ECE113**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:

Students should be able –

- To analyze fundamental concepts in antenna theory, including radiation fields and induction fields.
- To explore various radiating wire structures, including folded dipoles, monopoles, loops, helical antennas, horn antenna and antenna arrays.
- To develop knowledge of the radiation mechanism and various shapes of micro-strip patch antennas.
- To explore modern antennas, including SIW antennas, Vivaldi antennas, and meta-material antennas.
- To demonstrate the setup of experimental measurements for various antenna parameters, including radiation patterns, gain, phase polarization, terminal impedance, and directivity.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**BASIC PRINCIPLES AND DEFINITIONS:** Introduction, Retarded vector and scalar potentials. Radiation and induction fields. Radiation from elementary dipole (Hertzian dipole, short dipole, linear current distribution), half wave dipole, Antenna parameters, Different modes of propagation, and Multipath fading of radio waves.	7
Unit 2	**RADIATING WIRE STRUCTURES AND ANTENNA ARRAYS:** Folded dipole, Monopole, Biconical Antenna, Loop Antenna, Helical Antenna. Principle of pattern multiplication, Broadside arrays, Endfire arrays, Array pattern synthesis, Uniform Array, Binomial Array, Chebyshev Array, Antennas for receiving and transmitting TV Signals e.g., Yagi-Uda and Turnstile Antennas.	8
Unit 3	**APERTURE TYPE ANTENNAS:** Radiation from the rectangular aperture, E-plane Horns, H-plane Horns, Pyramidal Horn, Lens Antenna, Reflector Antennas, Broadband and frequency independent antennas, The frequency-independent concept: Rumsey's principle, Frequency independent planar log spiral antenna, Frequency independent conical spiral antenna and Log periodic antenna	8
Unit 4	**MICROSTRIP PATCH ANTENNA** Different parameters of a patch antenna, Basic characteristics, Radiation Mechanism, different shapes of a microstrip patch antenna, feeding techniques: coaxial coupling, proximity coupling, microstrip line coupling, aperture coupling; Radiation characteristics of the patch antenna.	6
Unit 5	**MODERN ANTENNAS FOR HIGH-FREQUENCY APPLICATION** SIW Antenna**,** Vivaldi Antenna, MIMO Antenna, Leaky wave Antenna, DRA, Circularly Polarized Antenna: Technique to generate circular polarization in patch antenna,	6
Unit 6	**ANTENNAS MEASUREMENTS:** Antenna Measurement Range, Vector Network Analyzer, VNA Calibration, Antenna positioner, Receiver Instrumentation, Experimental set ups for measurement of	7

	radiation patterns, gain, phase polarization, terminal impedance, circular polarization, and directivity.	

Course Outcomes: By the end of this course, the students will be able to	
1	Analyze radiation characteristics of various types of antennas, including elementary dipoles and half-wave dipoles.
2	Explore the characteristics and applications of various antennas, including folded dipoles, monopoles, bi-conical antennas, loop antennas, helical antennas and patch antennas. Also, analyze the principle of pattern multiplication in antenna arrays.
3	Explore the pyramidal horn antennas, lens antennas and reflector antennas including planar log spiral antennas and conical spiral antennas.
4	Analyze modern antennas, including SIW antennas, Vivaldi antennas, MIMO antennas, leaky wave antennas, DRA, and circularly polarized antennas.
5	Examine antenna measurement facilities and equipment, including antenna measurement ranges and Vector Network Analyzers (VNAs).

List of Simulations & Experiments		**No. of Turns**
1.	Design, simulation and analysis of dipole antenna using HFSS	2
2.	Design, simulation and analysis of spiral antenna using HFSS	2
3.	Design, simulation and analysis of microstrip patch antenna using HFSS	2
4.	Fabrication of designed microstrip patch antenna in PCB prototyping machine.	2
5.	VNA Calibration and S-parameter measurement of patch antenna using VNA	2
6.	Measurement of far-field characteristics of the designed patch antenna.	2
7.	Design and simulate one antenna resonating at 5.8 GHz featuring a 3 dB of gain and exhibiting a broadside radiation pattern.	2

Textbooks:		
S. No.	**Name of Book/ Authors/ Publishers**	**Year of Publication/ Reprint**
1	Antenna & Wave Propagation by Robert E. Collin, McGraw Hill	1985
2	Antenna Theory, Analysis and Design by Balanis A Constantine, 4th edition Wiley, New York	2021
Reference Books:		
S. No.	**Name of Book/ Authors/ Publishers**	**Year of Publication/ Reprint**
1	Antenna and Wave Propagation by Prasad KD, 3rd edition, Satya Prakashan, New Delhi	1996
2	Antennas (2nd Edition) by John D. Kraus, McGraw Hill	1997
3	Electromagnetic Waves and Radiating Systems (2nd Edition) by E.C.Jordan and K.G.Balmain, PHI	1995

4	Antennas and Wave Propagation by J. D. Kraus, R. J. Marhefka, A. S. Khan, McGraw Hill Education; Fourth edition	2017

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	"Antennas" IIT Bombay, Prof. Girish Kumar, https://nptel.ac.in/courses/108101092	NPTEL
2	"Analysis and Design Principles of Microwave Antennas", IIT Kharagpur, Dr. Amitabha Bhattacharya https://nptel.ac.in/courses/108105114	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	**H**	**H**	**H**	**H**					**M**				**H**	**H**
CO2	**H**	**H**	**H**	**H**					**M**				**H**	**H**
CO3	**H**	**H**	**H**	**M**					**M**				**H**	**M**
CO4	**H**	**H**	**H**	**H**					**M**				**H**	**M**
CO5	**H**	**H**	**L**	**M**	**H**				**M**	**M**			**H**	**H**

Course Name	**:**	**SEMICONDUCTOR PACKAGE MANUFACTURING**
Course ID	**:**	**ECE114**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:

Students should be able

- To analyze the basics of electronic device packaging and testing.
- To gain the knowledge for designing ICs for various applications.
- To examine the role of interconnections and assembly materials to meet electrical and mechanical requirements.
- To develop an understanding of inter-disciplinarity of packaging involving electrical, mechanical, thermal, materials, and processes.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**PACKAGE MANUFACTURING PROCESSES** Packaging Assembly Technology, Wafer Thinning, Dicing, Die Attach, Wire bonding, Flip Chip process, Flux Cleaning, Underfill, Encapsulation, Laser Marking, Solder Ball Attach, Reflow, Singulation, IC Packaging Toolsets & equipment operation, clean room operations	8
Unit 2	**SEMICONDUCTOR COMPONENT AND PACKAGE TEST** Overview of Testing methodologies, components tested & their characteristics, Challenges in testing, Types of Testers (Automated test Equipment & Benchtop Testers), Components & Subsystems of Testers, Principles of Functional Testing, Parametric/ Boundary Scan /In-Circuit Test/ Flying Probe Test, Test Data Analysis, Design for Testability & Tester Calibration & Maintenance, Future Trends	10
Unit 3	**ELECTRICAL AND PHYSICAL FAILURE ANALYSIS** Package failure modes, Failure detection mechanisms, Failure analysis tools, Test programs debugging, Data Analytics, ESD & EMI Management	8
Unit 4	**SEMICONDUCTOR PACKAGE MATERIALS AND QUALIFICATION** Reliability testing & qualification- MST/MSL, TC/TS, HAST & uHAST, Mold Compounds (Moldability), Underfill Materials, Die Attach Adhesives & Films, Substrate Technology, Bonding Wire, Solder & Dielectric materials	8
Unit 5	**INDUSTRIAL QUALITY AND STATISTICAL PROCESS CONTROL** Quality Control Plan (QCP) & Quality Management System (QMS), Incoming Material Inspection, In-Line Quality, Measurement System Analysis, Statistical analysis methods, Statistical Process Control (SPC), Fault Detection Control (FDC), Run-to-Run Control (R2R), Auto Defect Classification (ADC), Data Analytics, Machine Communication Protocol and System Integration	8

Course Outcomes: By the end of this course, the students will be able to	
1	Comprehend the manufacturing process of various semiconductor packages.
2	Describe various package materials, their testing and failure analysis.
3	Explain the package qualification methods and industrial quality management for the same.
4	Explain EMI and ESD effects, test program analysis and statistical process control of package manufacturing.

Suggested Books:

Text Book		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Semiconductor Packaging: Materials interaction and reliability, Andrea Chen and R. Yu Lo, CRC	2012
2	Semiconductor Manufacturing, H. Geng, TMH	Latest edition
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Gary S. May, Costas J. Spanos, Fundamentals of Semiconductor Manufacturing and Process Control (Wiley - IEEE)	2006
2	Semiconductor advanced packaging, John H. Lau, Springer	2021

Equivalent MOOCs courses:

S.No.	**Course Links**	**Offered by**
1	Electronic Manufacturing and Packaging https://nptel.ac.in/courses/112105267	NPTEL
2	Intro to Electronic Packaging https://ep.jhu.edu/courses/525607-intro-to-electronic-packaging/	Johns Hopkins University, United States

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

Course Name	**:**	**HDL BASED SYSTEM DESIGN**
Course ID	**:**	**ECE115**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:

Students should be able -

- To explore the syntax and various constructs of Verilog HDL language.
- To design the digital logic using various programmable logic devices.
- To develop the test benches using the system Verilog.
- To analyze the finite state machine modeling.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**BASIC VERILOG ELEMENTS** Lexical Conventions, Modules, Instances, Design Blocks, Stimulus Blocks, Data Types, Compiler Directives, Ports, Hierarchical Names, Tasks and Functions.	6
Unit 2	**MODELING IN VERILOG HDL** Gate-Level Modelling: Gate Types (And/ Or Gates, Buf/ Not Gates, Bufif/ NotifGates), Gate Delays (Rise, Fall and Turn-Off Delays, Min, Max, and Typical Delays). Data-Flow Modelling: Continuous Assignments, Delay Specification, Expressions, Operators, Operands, Operator Types. Behavioral modeling: Structured Procedures (initial and always), Procedural Assignments (Blocking and Non-Blocking Statements), Timing Controls, Conditional Statements, Multi-way Branching, Loops, Sequential and Parallel Blocks. Generate Blocks. Switch-Level Modelling: Switch modeling Elements.	10
Unit 3	**ADVANCED FEATURES OF VERILOG HDL** Procedural Continuous Assignments, Overriding Parameters, Conditional Compilation and Execution, Time Scales, Useful System Tasks, Timing and Delays (Delay Model Types, Path Delay modeling, Timing Checks, Delay Back-Annotation), User-Defined Primitives (Basics of UDPs, Combinational UDPs, Sequential UDPs, UDP Shorthand Symbols. Programming Language, Logical Synthesis: Introduction and Impact of Logic Synthesis, Verilog HDL Synthesis	8
Unit 4	**INTRODUCTION TO SYSTEM VERILOG** Introduction, data types, arrays, structures and unions, procedures and functions	8
Unit 5	**MODELING IN SYSTEM VERILOG** Finite state machine modeling, Design hierarchy, Interfaces, behavioral and transaction-level modeling.	10

List of Experiments:		**No. of Turns**
1	Write Verilog code to realize all the logic gates and flip-flops.	2
2	Write Verilog codes for combinational designs like encoders and decoders, multiplexers and de-multiplexers.	2
3	Write a Verilog code to describe the functions of a Full Adder using Data flow, gate level and behavioral modeling styles.	2

4	Write a Verilog code to model 8-bit ALU with logical and arithmetical operations.	2
5	Develop the Verilog code for a sequence detector using FSM modeling.	2
6	Design a 4-bit BCD counter (Synchronous reset and Asynchronous reset) using Verilog code.	1
7	Write Verilog code to display messages on an alphanumeric LCD.	1
8	Implement full adder and multiplexer on FPGA kit.	2

Course Outcomes: By the end of this course, the students will be able to	
1	Develop the codes for digital modules.
2	Construct various digital logic circuits by using advanced features of Verilog HDL language.
3	Develop the synthesizable circuits using logic synthesis tools.
4	Design and verify various circuits using test benches in system Verilog.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Verilog HDL: A Guide to Digital Design and Synthesis, S. Palnitkar, Prentice Hall NJ, USA	2003
2	A System Verilog Primer, by J. Bhasker	Latest edition
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Switching and Finite Automata Theory, ZviKohavi and Niraj K, Cambridge University Press, Third Edition.	2010
2	'Circuit design with VHDL' by Voleni A. Pedroni, MIT Press.	2011
3	System Verilog For Design: A Guide to Using System Verilog for Hardware Design, Stuart Sutherland, Simon Davidmann, Peter Flake, Springer Science	Latest edition

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Hardware modeling using Verilog by Prof. Indranil Sen Gupta https://archive.nptel.ac.in/courses/106/105/106105165/	NPTEL

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

Course Name	**:**	**EMBEDDED SYSTEMS DESIGN**
Course ID	**:**	**ECE116**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:

Students should be able -

- To examine the AVR microcontroller's architecture, its organization and programming.
- To design and encode an embedded system using high level language.
- To explore the various interfaces for system design.
- To explore advanced microprocessor's architecture and real time operating systems.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION TO EMBEDDED SYSTEMS** Basics of developing for embedded systems, embedded system initialization, Fundamentals of Microcontrollers for Embedded Systems, Embedded Versus External Memory Devices, CISC Versus RISC Processors, and Harvard Versus Von-Neumann architecture.	4
Unit 2	**AVR MICROCONTROLLER** ATmega16/32 Microcontroller (Basic architecture, Pin configuration, Memory organization (registers and i/o ports), Embedded C programming, Timers, on chip PWM, on chip ADC, Interrupts and Serial Communication.	10
Unit 3	**EMBEDDED PROGRAMMING** Introduction to C, Difference between C and Embedded C, Data Types used in Embedded C, Arithmetic & Logical Operators, Control Flow, If & If – else, While & Do – while, For, Switch & Case, Continue & Break, Array & String, Functions and Header files, Pointers	6
Unit 4	**INTERFACING** ADC and DAC interfacing, sensors and motors interfacing, display interfacing, serial interfacing	10
Unit 5	**ADVANCED MICROPROCESSOR** Real Time Operating System (RTOS), Types of real time tasks, Task Periodicity, Process state diagram, Kernel and Scheduler, Scheduling algorithms, Shared data (Resource) and Mutual Exclusion, Semaphore, Introduction to ARM, Features, ARM Pipeline, Instruction Set Architecture (ISA), Thumb Instructions, Exceptions in ARM, Embedded Wireless Protocols (Infrared Data Association (IrDA), Bluetooth, IEEE 802.11).	12

List of Experiments		**No. of Turns**
1	Familiarization with microcontroller platforms for system design and implementation.	1

2	Write assembly language program to 1. Multiply two 16-bit binary numbers. 2. Find the sum of first 10 integers. 3. Find the number of 0's and 1's in a 32-bit data. 4. Determine the given 16-bit number is ODD or EVEN. 5. Write data in RAM.	2
	Conduct the following experiments on Microcontroller board to	
3	Implement ADC & DAC interface with Microcontroller.	2
4	Implement a serial communication interface.	2
5	Interface a 4×4 keyboard and display the key code on an LCD.	1
6	Implement a VGA interface.	2
7	Implement a PS2 keypad interface.	2
8	Implement a 4-digit seven segment display.	1
9	Interface a Stepper motor and rotate it in clockwise and anti-clockwise direction.	1

Course Outcomes: By the end of this course, the students will be able to	
1	Describe the fundamental concept of embedded system design and complete architecture of the ATMEGA16/32 microcontroller.
2	Identify various on-chip peripherals of the ATMEGA16/32 microcontroller and their use in embedded applications.
3	To design FPGA and microcontroller based embedded systems using sensors and actuators.
4	Examine the ARM7 microcontroller architecture (32 bit) and wireless protocols.

Textbook:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Muhammad Ali Mazidi, "The AVR microcontroller and Embedded Systems using Assembly and C", 2nd Edition, Pearson Education	2008
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Frank Vahid / Tony Givargis, "Embedded System Design", Willey India, 2002.	2004
2	A.N. Sloss, D. Symes and C. Wright, "ARM System Developer's Guide: Design and Optimizing System Software", Morgan Kaman Publishers	2004
3	Santanu Chattopadhyay, "Embedded System Design", 1st Edition, PHI Learning, 2010	2003
4	David Simon, "An Embedded Software Primer", Addison Wesley	2000

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Introduction to FPGA Design for Embedded Systems https://www.colorado.edu/ecee/academics/online-programs/ms-ee-coursera/curriculum/embedded-systems/ecea-5360-introduction-fpga	University of Color Boulder

2	Embedded Systems Design https://onlinecourses.nptel.ac.in/noc20_cs14/preview	NPTEL

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

Departmental Elective Courses-IV

Course Name	**:**	**SATELLITE COMMUNICATION**
Course ID	**:**	**ECE117**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives
Students should be able- ● To acquire the basic technical knowledge of orbital dynamics and subsystems used in space and ground segments. ● To explore the orbit and satellite launching aspects. ● To investigate the effects of the transmission medium and navigational aspects. ● To analyze the impairments and mitigation techniques. ● To explore the utility of small satellites.

Total No. of Lectures – 42

Lecture wise breakup		**No. of lectures**
Unit 1	**ORBIT MECHANICS** A brief history and overview of Satellite Communications, achieving a Stable Orbit, Describing the Orbit of a Satellite (GEO, MEO and LEO satellite systems), Locating the Satellite, Look Angle Determination, Orbital Perturbations, Orbit Determination, Placing Satellites into Geostationary Orbit, Orbital Effects in Communications Systems Performance.	9
Unit 2	**SPACECRAFT SYSTEMS AND LINK DESIGN** Attitude and orbit control system, telemetry, tracking and command (TT&C), communications subsystems, transponders, and spacecraft antennas. Link design, Noise figure, and noise temperature, G/T ratio, CNR, CIR, Down link design, and Up link design.	9
Unit 3	**PROPAGATION EFFECTS** Propagation Phenomena, Propagation Impairment Attenuation and Depolarization, Counter measures, Rain and Ice Effects, Rain Attenuation Prediction.	7
Unit 4	**SATELLITE INSTALLATION** Installation basic principles, Velocity calculation, Inclination correction and circularization, Injection into orbit with a conventional launcher, Operations during installation, launch window, Environment during launching, and in the transfer environment. Satellite Imaging Technologies.	10
Unit 5	**VSAT SYSTEMS** VSAT Systems, Signal Formats, NGSO Satellite Systems, Packets and Protocols for NGSO Systems, Home Satellite TV, Digital DBS-TV. GPS Position Location Principles.	7

Course Outcomes: By the end of this course, the students will be able to	
1	Describe the communication satellite mechanics.

2	Illustrate the satellite's internal subsystems for communication applications.
3	Describe signal propagation effects in satellite communication.
4	Explain the satellite placement in orbit and launching techniques.
5	Calculate the power budget for satellite links.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Satellite communication (3rd Edition) by Timothy Pratt, Charles W. Bostian, John Wiley & Sons Publication	2020
2	Satellite Communications Systems: Systems, Techniques and Technology by Gérard Maral, Michel Bousquet, Zhili Sun	2020
3	Satellite Communications Systems Engineering (2ndEdition) by Wilbur Pritchard, Henri Suyderhoud, Pearson Education	2007
Reference books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Satellite Communication, P. Banerjee, PHI	2017
2	Satellite Communications by Dennis Roddy, Fourth Edition, McGraw-Hill	2017
3	Satellite Technology, Anil K. Maini, Varsha Agrawal, John Wiley & Sons Ltd	2014

Equivalent MOOCs courses:

Sr. No.	**Course Links**	**Offered by**
1.	Satellite Communication Systems by Prof. Kalyan Kumar Bandhyopadhyay (IIT Kharagpur), https://archive.nptel.ac.in/courses/	NPTEL

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

Course Name	**:**	**MEMS-BASED SENSORS AND ACTUATORS**
Course ID	**:**	**ECE118**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:

Students should be able -

- To study the fundamentals of sensors and actuators.
- To acquire the knowledge of MEMS technology.
- To apply the basic principle of MEMS-based sensors for specific applications.
- To apply the various deposition techniques for fabricating MEMS-based sensors.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION TO SENSORS & ACTUATORS:** 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 signals: Pneumatic signal; Hydraulic signal; Electronic Signal. Principle of operation, construction details, characteristics and applications of the potentiometer, Proving Rings, Strain Gauges, Resistance thermometer, Thermistor, Hot-wire anemometer, Resistance Hygrometer, and Photo-resistive sensor.	**9**
Unit 2	**MICROELECTRONICS BASED SYSTEMS:** Basic Structures of MEMS Devices, Canti Levers, Fixed Beams diaphragms, Broad Response of Micro Electromechanical Systems (MEMs) to Mechanical (force, pressure, etc.), Thermal, Electrical, Optical and Magnetic Stimuli, Compatibility of MEMs from the points of Power Dissipation, Leakage etc.	**9**
Unit 3	**MEMS BASED SENSORS:** MEMs technology fabrication (Bulk micro machining and Surface micro machining), Design of Acoustic wave sensors, resonant sensors, Vibratory gyroscopes, Capacitive and Piezo Resistive Pressure sensors- engineering mechanics behind these Microsensors. Case study: Piezo-resistive pressure sensor.	**8**
Unit 4	**MEMS BASED ACTUATORS:** Design of Actuators, Actuation using thermal forces, Actuation using shape memory Alloys, Actuation using piezoelectric crystals, Actuation using Electrostatic forces (Parallel plate, Torsion bar, Comb drive actuators), Micromechanical Motors and pumps. Case study: Comb drive actuators	**8**
Unit 5	**SENSOR MATERIALS AND PROCESSING TECHNIQUES:** Materials for sensors: Silicon, Plastics, metals, ceramics, glasses, nano materials Processing techniques: Vacuum deposition, sputtering, chemical vapor deposition, electro plating, photolithography, silicon micro machining, Bulk silicon micro machining, Surface silicon micro machining, LIGA process.	**8**

Course Outcomes: By the end of this course, students will be able to	
1	Analyze the fundamentals of sensors and actuators.
2	Explore the knowledge of MEMS technology.
3	Apply the basic principle of MEMS-based sensors for specific applications.
4	Apply the various deposition techniques to fabricate MEMS-based sensors.

Textbook:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Marc Madou, "Fundamentals of Micro fabrication", CRC press 1997	Latest Edition
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Patranabis.D, "Sensors and Transducers", Wheeler publisher, 1994	Latest Edition
2	Tai Ran Hsu, "MEMS and Microsystems Design and Manufacture", Tata McGraw Hill, 2002.	Latest Edition
3	Jacob Fraden, "Hand Book of Modern Sensors: Physics, Designs and Application" Fourth edition, Springer, 2010.	Latest Edition
4	Massood Tabib and Azar, "Microactuators Electrical, Magnetic, thermal, optical, mechanical, chemical and smart structures", First edition, Kluwer academic publishers, Springer, 1997	Latest Edition

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Fabrication Techniques for MEMs-Based Sensors https://archive.nptel.ac.in/courses/108/108/108108113/	NPTEL
2	Sensors and Actuators https://onlinecourses.nptel.ac.in/noc21_ee32/preview	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	**H**	**M**	**M**	**M**					**H**				**H**	**H**
CO2	**H**	**M**	**M**	**L**					**H**				**H**	**H**
CO3	**H**	**M**	**M**	**L**					**H**				**H**	**H**
CO4	**H**	**M**	**H**	**H**					**H**				**H**	**H**

Course Name	**:**	**VLSI VERIFICATION AND TESTING**
Course ID	**:**	**ECE119**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:

Students should be able -

- To analyze the use of procedural statements and routines in testbench design with system Verilog.
- To explore the use of multi-threading and inter-process communication in testbench design.
- To apply randomization concepts in designing a testbench.
- To develop an Interface for a system Verilog testbench with system C.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION** Role of testing in VLSI design, Issues in test and verification of complex chips, VLSI test process and equipment, Test economics, Yield analysis and product quality.	**6**
Unit 2	**FAULT MODELLING AND FAULT SIMULATION** Physical faults and their modeling, Stuck-at faults, bridging faults, Fault collapsing, Fault simulation, Deductive, Parallel and Concurrent fault simulation, Combinational and sequential SCOAP measures.	**10**
Unit 3	**ATPG FOR COMBINATIONAL CIRCUITS** D-Algorithm, Boolean Difference, PODEM, Random, Exhaustive and Weighted Test Pattern Generation, Aliasing and its effect on Fault coverage.	**6**
Unit 4	**ATPG FOR SEQUENTIAL CIRCUITS** ATPG for Single-Clock Synchronous Circuits, Time frame expansion method, Simulation-Based Sequential Circuit ATPG.	**6**
Unit 5	**MEMORY TESTING AND BIST** Permanent, Intermittent and pattern-sensitive faults, March test notion, Memory testing using march tests, PLA testing, Ad-Hoc DFT methods, Scan design, Partial scan design, Random logic for BIST, Memory BIST.	**7**
Unit 6	**VERIFICATION** Design verification techniques based on simulation, Analytical and formal approaches, Functional verification, Timing verification, Formal verification, Basics of equivalence checking and model checking, Hardware emulation.	**7**

List of Experiments:		**Number of Turns**
1	Introduction to test bench architecture.	1
2	Development of an exhaustive test bench for the 1-bit full adder. Language: Verilog	1

3	Development of exhaustive test bench for 16X1 Multiplexer using file reading writing features. Language: Verilog	1
4	Development of layered testbench components for functional verification of 8-bit ALU. Language: System Verilog	2
6	Development of layered testbench components for functional verification of synchronous FIFO. Language: System Verilog	2
7	Development of layered testbench components for functional verification of Round Robin Arbiter. Language: System Verilog	1
8	Analysis of code coverages and write development of functional coverage. Functional Coverage: Model sim or Questa sim	2
9	Design for Test and Automatic Test pattern Generation for a 4-bit counter.	2
10	Perform the logic equivalence (formal verification).	2

Course Outcomes: By the end of the course, the students will be able to	
1	Analyze fault modeling and collapsing.
2	Classify various combinational and sequential automatic test pattern generation techniques.
3	Analyze different memory faults and their testing methods.
4	Develop the verification plan for small to complex VLSI designs.
5	Develop test-bench using HDL for testing and verification of VLSI designs.

Textbook:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Delay Fault Testing for VLSI Circuits, A. Krstic and K-T Cheng,3rd Kluwer Academic Publishers, 2003	Latest Edition
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits, 2002.	Latest Edition
2	Testing of Digital Systems, N. K. Jha and S. Gupta, 2nd, Cambridge University Press. 2003.	Latest Edition
3	Fault Tolerant and Fault Testable P. K. Lala, 4th, Hardware Design, Prentice-Hall, 2020.	Latest Edition
4	Chris Spear, System Verilog for Verification, Springer, 2014.	Latest Edition

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**

1	VLSI Design Verification and test https://archive.nptel.ac.in/courses/117/103/117103125/	NPTEL
2	Digital VLSI Testing https://onlinecourses.nptel.ac.in/noc20_ee76/preview	Swayam

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

Course Name	**:**	**DIGITAL IMAGE PROCESSING**
Course ID	**:**	**ECE120**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:

Students should be able –

- To develop the understanding of image fundamentals and mathematical transforms for image processing and image enhancement.
- To explore image segmentation and representation techniques.
- To apply techniques to extract the features of interest from the input image.
- To explore the concepts of image compression and image fusion.
- To analyze the constraints in image processing when dealing with 3D data sets.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**FUNDAMENTALS OF IMAGE PROCESSING**: Introduction, Human visual system, Steps in image processing systems, Image acquisition, Sampling and Quantization, Pixel relationships, Light, brightness adaption and discrimination, Color fundamentals and models, File formats, Image operations, Arithmetic, Geometric and Morphological.	9
Unit 2	**IMAGE ENHANCEMENT**: Basics of intensity transform and spatial domain, gray level Transformations, Contrast stretching, Thresholding, Image negative, Log transformation, Power-low transformation, Intensity level slicing and Bit-plane slicing, Histogram processing, Histogram equalization process, Spatial filtering smoothing and sharpening, Filtering in the frequency domain, Fourier transform of sampled function, DFT, FFT, DCT, Image smoothing and sharpening filters – Homomorphic Filtering	9
Unit 3	**IMAGE SEGMENTATION AND FEATURE ANALYSIS:** Fundamentals, Detection of Discontinuities, Edge operators, Edge linking and Boundary Detection, Thresholding, Edge-based segmentation, Region-based segmentation, Region split and merge techniques, Morphological Watersheds, Motion Segmentation, spatial techniques and frequency domain techniques, feature analysis and extraction.	8
Unit 4	**MULTI RESOLUTION ANALYSIS AND COMPRESSIONS**: Multi-resolution analysis: Image Pyramids, resolution expansion, Wavelet Transforms, Image compression: Fundamentals, Image compression models, Elements of Information Theory, Error-free compression, Lossy Compression, Image formats, and Compression Standards, Basic compression methods: Huffman coding, Arithmetic coding, LZW coding, JPEG compression standard.	8
Unit 5	**APPLICATION OF IMAGE PROCESSING:** Image classification, Image recognition, Image fusion, Steganography, Color Image Processing, Color models, Pseudo-color image processing, Pattern recognition.	**8**

List of Experiments:		No. of Turns
1	Hands-on Experience with MATLAB/Open-source software to extract different attributes of an Image.	2
2	Write and execute a program for Image Negation/Power Law Transformation	2
3	Write and execute the program for Histogram Mapping, Equalization and Chain coding.	2
4	Determine the effect of Image smoothening, sharpening, and Pseudo coloring on images.	2
5	Analyze the effect of different edge detectors such as Sobel, Prewitt, and Robert's operators.	1
6	To understand various image noise models and write programs for Image restoration, remove salt and pepper noise, minimize Gaussian noise and Median/Weiner filter.	2
7	Write and execute a program to analyze the Morphological operations on Binary images.	1
8	Determine the effect of the application of FFT and DCT on different types of images.	2

Course Outcomes: By the end of the course, the students will be able to	
1	Apply image processing techniques in both the spatial and frequency domains.
2	Analyze image formation and the role of the human visual system in the perception of gray and color image data.
3	Design image analysis techniques in the form of image segmentation and to evaluate the methodologies for segmentation.
4	Conduct independent study and analysis of feature extraction techniques.
5	Apply image processing algorithms in practical applications.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Digital Image Processing by R.C. Gonzalez and R.E. Woods, Addison-Wesley, 2009.	2009
2	Computer Vision: A Modern Approach by D.A. Forsyth and J. Ponce, Prentice Hall, 2011.	2011
3	Digital Image Processing and Computer-Vision by R.J. Shalkoff, John Wiley and Sons, New York, 2000.	2000
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Fundamentals of Digital Image Processing by Anil K. Jain, Pearson Education, 1989.	1989

2	A Mathematical Introduction to Compressive Sensing by Simon Foucart and Holger Rauhut, Birkhauser, 2013	2013
3	Biomedical Signal Analysis by Rangaraj M Rangayyan, IEEE Press, 2001	2001
4	Natural Image Statistics by Aapo Hyvarinen, Jarmo Hurri and Patrick Hoyer, Springer Verlag 2009.	2009

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	Digital Image Processing by Prabir Kumar Biswas, (IIT Kharagpur), https://onlinecourses.nptel.ac.in/noc22_ee116/preview	NPTEL
2	Computer Vision and Image Processing – Fundamentals and Applications by Prof. M.K. Bhuyan, (IIT Guwahati) https://nptel.ac.in/courses/108103174	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	**H**	**M**	**M**	**M**	**H**				**H**				**H**	**H**
CO2	**H**	**L**	**L**	**L**	**H**				**M**				**H**	**H**
CO3	**H**	**M**		**L**	**H**				**M**				**H**	**H**
CO4	**H**	**M**		**M**	**H**				**M**				**H**	**H**
CO5	**H**	**H**	**H**	**H**	**H**				**H**	**M**			**H**	**H**

Departmental Elective Courses-V

Course Name	**:**	**INFORMATION THEORY AND CODING**
Course ID	**:**	**ECE101**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:

Students should be able -

- To develop an understanding of information, entropy, and channel capacity and their significance in communications systems.
- To explore channel capacity calculations to support error-free transmission.
- To apply various types of source coding algorithms and analyze their performance for efficient data compression in communication systems.
- To develop various methods of generating and detecting different types of error-correcting codes.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**BASIC CONCEPTS OF INFORMATION THEORY** Shannon measure of information, Entropy, Joint and conditional entropy, Kullback–Leibler distance and Mutual information, Chain Rule for Entropy, Various inequalities useful in information theory, Markov processes and Entropy rates	10
Unit 2	**DATA COMPRESSION TECHNIQUES AND CHANNEL CAPACITY** Asymptotic equipartition property (AEP) theorem, Consequences of the AEP: Data Compression, High-probability sets and the typical set, Examples of source codes, Kraft Inequality, Optimal Codes, Bounds on the optimal code length, Kraft inequality for uniquely decodable codes, Huffman codes, Shannon–Fano–Elias coding. Capacity evaluation of various binary channels, capacity evaluation of symmetric channels (Strongly and Weakly symmetric discrete memoryless channels), Channel coding theorem, Source-channel separation theorem	12
Unit 3	**LINEAR BLOCK CODES** Generator matrix and parity check matrix, Weights and distance for linear block codes, Hamming codes, Syndrome decoding, bounds on the minimum distance of linear block codes (Singleton and Hamming Bound); Cyclic codes: Properties, Encoding and decoding of cyclic codes	8
Unit 4	**CONVOLUTION CODES** Structure of convolutional codes (trellis representation), Encoding of convolutional codes, Transfer function of convolutional codes, Decoding of convolutional codes using Viterbi algorithm.	4
Unit 5	**BROADCAST CHANNEL** Superposition coding scheme and its optimality for the degraded broadcast channel, Relation between the capacity region of Gaussian BC and MAC.	4
Unit 6	**CHANNEL CODING FOR MULTI USERS** Introduction, Block codes for the binary adder channel, Trellis codes for the multiple access channel.	4

Course Outcomes: By the end of this course, students will be able to	
1	Implement the various types of source coding algorithms and analyze the concepts of self-information, entropy and mutual information.
2	Evaluate the capacity for discrete memory-less channels and get an understanding of the channel coding theorem and source-channel separation theorem.
3	Design error control coding techniques using linear block codes and cyclic codes (encoding and decoding).
4	Analyze the superposition coding scheme for the broadcast channel and the concept of channel coding for multiple users.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Elements of Information Theory, by Thomas Cover and Joy Thomas, 2nd edition, Wiley- Interscience	2006
2	A Course in Error Correcting Codes, by Jorn Justesen and Tom Hoholdt, 1st edition, Hindustan Book Agency.	2012
3	Network Information Theory by A. El Gamal and Y. H. Kim, Cambridge	2011
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Digital Communications, by John Proakis and Masoud Salehi, 5th edition, McGraw-Hill	2008
2	Principles of digital communication by J. Das, S. K. Mullick and P.K. Chatterjee, Wiley	1986
3	Information Theory and Coding by Murlidhar Kulkarni and K.S. Shivaprakasha, Wiley	2014

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	An Introduction to Information Theory by Prof. Adrish Banerjee (IIT Kanpur). https://onlinecourses.nptel.ac.in/noc22_ee49/preview.	NPTEL
2	Information Theory and Coding by Prof. S.N. Merchant (IIT Bombay). https://nptel.ac.in/courses/117101053.	NPTEL

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

Course Name	**:**	**SEMICONDUCTOR DEVICE MODELLING**
Course ID	**:**	**ECE102**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:

Students should be able-

- To analyze the concept of numerical modeling and different finite element methods.
- To apply transport equations for different MOS architectures.
- To apply quantum models in advance semiconductor devices.
- To design and develop nano-scale device architectures.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION TO NUMERICAL MODELING:** Fundamental semiconductor equations, Finite difference scheme, Error analysis, Solution of a system of Linear Equations, Direct Method: LU-decomposition, Tri-diagonal system, Relaxation Method, Numerical solution of Non-Linear Equations: Newton Raphson method, Finite difference discretization example: Current continuity and energy relations, Introduction to circuit simulations	8
Unit 2	**DRIFT-DIFFUSION TRANSPORT MODEL:** Equations, Boundary Conditions, Mobility and Generation / Recombination, Energy band diagrams, Explain the concept of crystal momentum, ε-k and ε-x diagrams of a semiconductor, ε-k diagrams of Si and GaAs	8
Unit 3	**MOSFET MODELS:** Structure and Characteristics, Qualitative Model, Equations, Boundary Conditions and Approximations, Surface Potential and Threshold solutions, Testing, Improvement and Parameter Extraction	10
Unit 4	**QUANTUM PHYSICS ASPECTS OF DEVICE MODELING:** Effective mass Schrödinger equation, Matrix representation, Dirac notation, WKB Approximation, Time-dependent and independent perturbation theories, Fermi's golden rule, semiclassical transport in semiconductors: Boltzmann transport equation, numerical scheme, Introduction to Monte Carlo simulations	8
Unit 5	**QUANTUM EFFECTS:** Double barrier resonant tunneling diode, Device modeling through transfer matrix approach, Numerical estimation of diode current density, coupled Poisson-Schrödinger scheme for electron transmission simulations	8

Course Outcomes: By the end of this course, the students will be able to	
1	Analyze the transport phenomena in semiconductors.
2	Illustrate the E-k and E-x diagrams for various semiconductor devices.

3	Recognize the basic operation principles involved in the modeling of devices.
4	Analyze Classical, Semi-classical and Quantum modeling techniques.
5	Model the different architectures of semiconductor devices.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	M. Lundstrom,"Fundamentals of Carrier Transport", Cambridge University Press, 2000.	2000
2	C.Snowden, "Introduction to Semiconductor Device Modeling", World Scientific, 1986	1986
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Y. Tsividis and C. McAndrew, "MOSFET modeling for Circuit Simulation", Oxford University Press, 2011	2011
2	Semiconductor Device and Modeling, Nandita Das Gupta, Amitava Das Gupta	2004
3	BSIM Manuals available on BSIM homepage on the internet	
4	Relevant Research Papers	

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Semiconductor Device Modeling https://archive.nptel.ac.in/courses/117/106/117106033/	NPTEL
2	Semiconductor Device Modeling and Simulation https://nanohub.org/resources/37981#series	Nanohub

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

Course Name	**:**	**MEASUREMENT TECHNIQUES**
Course ID	**:**	**ECE103**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives
Students should be able - ● To analyze the various measurement techniques and methods. ● To explore the basic working of different instruments used for measurement. ● To explore the parameters for measurement through software tools. ● To analyze the importance of signal generators and analyzers in measurement.

Total No. of lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INSTRUMENTATION SCHEMES & CHARACTERISTICS:** Methods of measurements, instrument classification, Functional Elements of an instrument, input-output configuration of measuring instruments, Error analysis, Methods of Correction for interfering and modifying inputs, Standards, calibration, Accuracy, Fidelity, Precision, Loading effects, selection of instruments, Measurement systems–Static and dynamic Characteristics.	10
Unit 2	**VIRTUAL INSTRUMENTATION:** Familiarization and use of Virtual Instrumentation, Analysis of analog and digital signals, signal processing, designing GUI to measure and analyze the real-time signals, interfacing with RS-232 and VISA, etc.	12
Unit 3	**DATA ACQUISITION AND MEASUREMENT**: Basics of data acquisition: Transducer and Signal Conditioning, sampling rate and aliasing, Data acquisition systems, measurement of current, voltage, power, power factor and energy indicating instruments, Bridge measurement, Various bridges for impedance and frequency measurement.	12
Unit 4	**SIGNAL GENERATORS & ANALYZERS:** Function generator, RF signal generator, Sweep Frequency generator, Frequency synthesizers, Wave analyzer, Harmonic distortion analyzer, Spectrum analyzer, DSO, Digital display devices & Recorders.	8

List of Experiments:		**No. of Turns**
1	To study the performance characteristics of an LVDT.	**2**
2	Measurement of inductance and capacitance using Bridges.	**2**
3	Design an astable multivibrator circuit and verify the frequency of its output signal.	**2**
4	To study the waveforms of various signals while using CRO and Spectrum analyzer.	**2**

5	To study a temperature control system.	**2**
6	Design a system for any real-time application to acquire the signal from any transducer/Sensor and process it to control any appliance.	**2**
7	Measurement of power in a single-phase circuit	**1**
8	To study and implement the serial communication between two devices by RS-232 protocol.	**2**

Course Outcomes: By the end of this course, the students will be able to	
1	Explore the fundamentals of electronic instrumentation.
2	Measure various electrical parameters with accuracy, precision and resolution.
3	Use a signal generator, frequency counter, DSO and digital IC tester for appropriate measurement.
4	Learn the concepts and basics of LabVIEW.
5	Measure frequency, phase and other parameters using measuring devices such as Spectrum analyzer, DSO, etc.

Suggested Books:

Text Books:	
Sr. No.	**Name of Book/Authors/Publisher**
1. **2.** **3.**	Robert H. Bishop, "Learning with LabVIEW™ 7 Express", Pearson Education, Delhi, India, 2005. Sanjay Gupta & J.John, "Virtual Instrumentation Using LabVIEW", Electrical Engineering Series, The Tata McGraw-Hill, New Delhi, India. Electronics measurements and instrumentation by A.K.Sawhney LabVIEW manual. Web Resources: 1. www.ni.com 2. www.ltrpub.com

Reference Books:	
Sr. No.	**Name of Book/Authors/Publisher**
1. **2.**	Gary Johnson, "LabVIEW Graphical Programming", 2nd Edition, McGraw Hill, New York, 1997. Lisa K. wells & Jeffrey Travis, "LabVIEW for everyone", Prentice Hall, New Jersey, 1997.

Equivalent MOOC courses:

Sr. No.	**Course Links**	**Offered By**
1.	Electrical Measurement and Electronic Instruments, by Prof. Avishek Chatterjee IIT Kharagpur https://nptel.ac.in/courses/108105153	NPTEL
2	Transducers for Instrumentation, by Ankur Gupta IIT Delhi https://nptel.ac.in/courses/108102191	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	**H**	**M**	**M**	**L**	**M**				**M**				**H**	**H**
CO2	**H**	**H**	**M**	**H**	**H**				**M**				**H**	**H**
CO3	**H**	**H**	**M**	**M**	**H**				**M**				**H**	**H**
CO4	**H**	**M**	**H**	**H**	**H**				**M**				**H**	**H**
CO5	**H**	**M**	**M**	**H**	**H**				**M**	**M**			**H**	**H**

Course Name	**:**	**FPGA and ASICs**
Course ID	**:**	**ECE104**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:

Students should be able-

- To develop the understanding of FPGA architecture and digital design techniques using FPGA.
- To explore various ASIC architectures and ASIC design flow.
- To explore the issues in ASIC design techniques.
- To configure FPGAs and analyze code synthesis.

Total No. of Lectures −42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION:** VLSI Design Flow, Design Hierarchy, Structured Design Strategies, VLSI Design Styles, Chip Design Options, FPGA Design Flow, Role of FPGAs, FPGA Types, FPGA vs Custom VLSI, ASIC Design Flow, Type of ASIC, Full custom ASIC, Gate Array Based ASIC and Types of Arrays, Standard Cell Based ASIC, Timing and Electrical Characteristics, Power Dissipation, Case Studies and Economics of ASIC	10
Unit 2	**PROGRAMMABLE LOGIC DEVICES:** Introduction, Evolution, PROM, PLA, PAL, GAL, Applications, Design Flow, Programmable Interconnections	4
Unit 3	**FUNDAMENTALS OF FPGA:** A Simple Programmable Function, Fusible Link Technologies, Anti-Fuse Technologies, Static RAM based Technologies, E-PROM, EE-PROM, Flash Based Technologies, Permanently Programmed FPGAs, Chip I/O, Circuit Design of FPGA fabrics.	8
Unit 4	**FPGA ARCHITECTURES:** Fine, Medium-Grained, Coarse-Grained, MUX and LUT Based Design, CLBs, LABs and Slices, Fast-Carry Chains, Embedded RAMs, Embedded Multipliers, Adders, MACs Embedded Processor Cores, Clock Trees and Clock Managers, General Purpose I/Os, Gigabit Transceivers, Hard IP, Soft IP and Firm IP, System Gates versus Real Gates.	5
Unit 5	**CONFIGURING FPGA:** Configuration files, Configuration Ports, JTAG in brief, Programming using JTAG port.	4
Unit 6	**ASIC LIBRARY DESIGN:** Transistor as Resistor, Transistor Parasitic Capacitance, Logical Effort, Predicting Delay, Logical Area, Logical paths, multistage cells, Optimum Delay, Library Cell Design.	6
Unit 7	**LOGICAL SYNTHESIS AND DESIGN TOOLS:** Physical Design Compilation, Simulation, and Implementation, Design Flow, Tools for Simulation and Synthesis, Case Studies based on designing and synthesis of various digital systems.	5

Course Outcomes: By the end of this course, the students will be able to	
1	Explain in detail various FPGA architectures.
2	Design digital circuits using field programmable gate arrays.
3	Analyze programmable ASIC design flow and low-level design methodologies.
4.	Identify various design tools and logic synthesis tools.
5.	Explain various Programmable Logic Devices.

Textbooks:		
Sr. No.	**Name of the Book/Author/Publisher**	**Year of publication**
1	Design Warriors Guide to FPGA by Clive Max, Elsevire.	2004
2	M.J.S. Smith, ―Application Specific Integrated Circuits, Pearson Education, 2008 R2 Wayne Wolf, ―FPGA	2008
Reference Books:		
Sr. No.	**Name of Book/Authors/Publisher**	**Year Of Publication /Reprint**
1.	Wayne Wolf, ―FPGA,Based System Design, Prentice Hall PTR,.	2009
2.	Verilog HDL: A Guide to Digital Design and Synthesis, S. Palnitkar, Prentice Hall NJ, USA	2003
3.	Circuit design with VHDL' by Voleni A Pedroni, MIT Press.	2011
4	Michad John, Sebastian Smith "Application Specific Integrated Circuit", Pearson Education, LPE.	2006

Equivalent MOOC courses:

Sr. No.	**Course Links**	**Offered By**
1.	'Digital Systems Design with PLDs and FPGAs' by Prof. Kuruvilla Varghese, Department of Electronic Systems Engineering, Indian Institute of Science – Bangalore https://archive.nptel.ac.in/courses/117/108/117108040/	NPTEL

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

OPEN ELECTIVE COURSES

Course Name	**:**	**ARDUINO PROGRAMMING AND RASPBERRY PI**
Course ID	**:**	**ECO101**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:

Students should be able-

- To explore the components, features and architecture of AVR microcontroller.
- To design an electronics system using Arduino.
- To explore the basic functionality and configuration of Raspberry Pi and analyze the programming and interfacing with Raspberry Pi.
- To explore Python programming language on Raspberry Pi.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**EMBEDDED SYSTEM DESIGN: BASICS** Introduction to embedded systems, Components of embedded system. Advantages and applications of embedded systems, Examples of real-time embedded systems and how they are manufactured industry-ready, Different Microcontroller Architectures (CISC, RISC, ARISC), Internal Resources & Hardware Chips in Details, History of AVR Microcontrollers and Features, Memory Architectures (RAM/ROM).	10
Unit 2	**LEARNING ARDUINO PLATFORM:** Introduction to ARDUINO, ARDUINO History and Family, General Programming and Hardware Interfacings with Arduino, basic sensors and actuators using Arduino, controlling embedded system-based devices using Arduino.	8
Unit 3	**GETTING STARTED WITH RASPBERRY Pi:** Basic functionality of the Raspberry Pi board and its Processor, setting and configuring the board, differentiating Raspberry Pi from other platforms like Arduino, Begal, Asus thinker, etc., Overclocking, Component overview.	8
Unit 4	**PROGRAMMING THE RASPBERRY Pi:** Introducing Python programming language: Python Programming Environment, Python Expressions, Strings, Functions, Function Arguments, Lists, List Methods, Control Flow, Numpy, PIP (Python Installation Package), and customized libraries.	8
Unit 5	**EXPLORING ELECTRONICS WITH THE RASPBERRY Pi:** Communication facilities on Raspberry Pi (I2C, SPI, UART), working with RPi. GPIO library, Interfacing of Sensors and Actuators.	8

Course Outcomes: By the end of this course, the students will be able to:	
1	Illustrate how the Arduino platform works in terms of the physical board, libraries, and the IDE (Integrated Development Environment).
2	Program Arduino using C code and access the pins on the board via the software to control external devices.
3	Analyze the working and programming of Raspberry Pi, its features, and how various components can

	be used with it.
4	Develop an understanding of interfacing of components with Raspberry Pi.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	Margolis, M. Arduino cookbook: Recipes to begin, expand, and enhance your projects. O'Reilly Media, Inc.	2011
2.	ARM System Developer's Guide -Designing and Optimizing System Software by: Andrew N Sloss, Dominic Symes, Chris Wright;Elseiver	2004
3.	Mark Lutz, "Learning Python", O'Reilly Media, 5th Edition.	2016
Reference books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	The official raspberry Pi Projects Book: https://www.raspberrypi.org/magpi-issues/Projects_Book_v1.pdf	NA
2.	Raspberry Pi Assembly Language RASPBIAN Beginners THIRD EDITION, CreateSpace Independent Publishing Platform.	2013

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Introduction to Internet of Things https://onlinecourses.nptel.ac.in/noc22_cs53/preview	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	**H**	**M**	**M**						**H**				**H**	**H**
CO2	**H**	**H**	**H**	**H**	**L**				**H**				**H**	**H**
CO3	**H**	**M**	**M**						**H**				**H**	**H**
CO4	**H**	**H**	**H**	**H**	**M**				**H**				**H**	**H**

Course Name	**:**	**COMPUTER NETWORKS**
Course ID	**:**	**ECO102**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:

Students should be able-

- To explore the concepts of data communication and networks in the real world.
- To define the various layers of the OSI Model and their functionalities.
- To apply the channel allocation, framing, error, and flow control techniques.
- To develop network architecture, assign IP addressing and apply various routing algorithms to find the shortest paths for network-layer packet delivery.
- To analyze the computer network infrastructure and study various security mechanisms in real-world applications.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**OVERVIEW OF DATA COMMUNICATION AND NETWORKING** Data communications, Networks, The Internet, Protocols and standards, Layered tasks, OSI model, TCP /IP protocol Architecture, History of the computer network, Internetworking Devices, an overview of SS7, Diameter and Sigtran protocols	3
Unit 2	**PHYSICAL LAYER** Data rate limit, Transmission impairments, Line coding, Block coding, Sampling, Transmission mode, Modulation of digital data, Telephone modems, Modulation of analog signal, FDM, WDM, TDM, Guided media, Unguided media	5
Unit 3	**DATA LINK LAYER** Types of errors, Detection, Error correction, Flow and error control, Stop and wait ARQ, go back n ARQ, Selective repeat ARQ, HDLC, point-to-point protocol, PPP stack, Random access (ALOHA, CSMA), Controlled access (Reservation, Polling, Token Passing), Channelization (FDMA, TDMA, CDMA), Traditional Ethernet, Fast Ethernet, Gigabit Ethernet	8
Unit 4	**NETWORK LAYER** Repeaters, Bridges, Type of Bridges, Routers, Routing concepts, Gateways, Internetworks, ARP, IP, ICMP, IPV6, Unicast routing, Unicast routing protocol, Multicast routing, Multicast routing protocols, introduction to Security, Cryptography, and SSL, Security - firewalls, DoS, etc.	6
Unit 5	**TRANSPORT LAYER** Process to process delivery, User datagram protocol (UDP), Multiplexing and Demultiplexing, Connection less transport (UDP), Principles of reliable data transfer, Transmission control protocol (TCP), Data traffic, Congestion, Congestion control, Quality of service	4
Unit 6	**PRESENTATION LAYER AND SESSION LAYER** Session layer function, Token Management, and Session Layer Protocols, Presentation layer function and Protocols	4

Unit 7	**APPLICATION LAYER** DNS, Electronics mail architecture and services, message formats and transfers, WWW architectural overview, static and dynamic web pages, HTTP, Digital audio and video	4
Unit 8	**WIRELESS NETWORKS AND SWITCHING** Cordless system, WiMAX and IEEE 802.16 broadband wireless access standards, Mobile IP, Wireless Application Protocol, IEEE 802 Architecture, IEEE 802.11 Architecture and Services, IEEE 802.11 Medium Access Control, IEEE 802.11 Physical Layer, Other IEEE 802.11 Standards, Wi-Fi Protocol Access, Bluetooth and IEEE 802.15, LTE. Emerging Applications: NFC, RFID, VoIP, SIP, video over P2P, VolTE Switching: Circuit Switching, Space division switching, Time division switching, Space and time division switching combinations, Packet switching, Data gram approach, Virtual circuit approach, message switching.	8

Course Outcomes: By the end of the course, the students will be able to	
1	Describe the computer network system and its communication.
2	Classify and compare the various layers of a computer network model, their role, and characteristics.
3	Apply the concepts of channel allocation, framing, error, and flow control techniques.
4	Analyze the various wireless network models.
5	Implement various protocols (using NetSim software) and prepare a comprehensive case study of the computer network infrastructure.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Data Communication & Networking by Behrouz A. Forouzan, 6th edition, McGraw Hill	2022
2	Computer Networking: A Top-Down Approach by James F. Kurose and Keth W. Ross, 8th edition, Pearson Education	2022
3	Computer Networks by Andrew S. Tanenbaum, Nick Feamster and David J. Wetherall, 6th edition, Pearson Education	2022
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Computer Networks: A Systems Approach by Larry L. Peterson and Bruce S. Davie, 6th edition, Elsevier Science	2021
2	Data and Computer Communications by William Stallings, 10th edition, Pearson Education	2017
3	Data Communication and Distributed Networks by Ulylers D. Black, 3rd edition, Prentice Hall India Learning Private Limited	1994

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	Computer Networks and Internet Protocol by Prof. Soumya Kanti Ghosh Prof. Sandip Chakraborty (IIT Kharagpur) https://onlinecourses.nptel.ac.in/noc21_cs18/preview	NPTEL
2	Computer Networking by Nick Feamster **(**Georgia Institute of Technology**)**. https://www.my-mooc.com/en/mooc/computer-networking--ud436/	Udacity

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

Course Name	**:**	**SEMICONDUCTOR PACKAGE MANUFACTURING**
Course ID	**:**	**ECO103**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:

Students should be able-

- To analyze the basics of electronic device packaging and testing.
- To gain the knowledge for designing ICs for various applications.
- To examine the role of interconnection and assembly materials to meet electrical and mechanical requirements.
- To develop an understanding of inter-disciplinarity of packaging involving electrical, mechanical, thermal, materials, and processes.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**PACKAGE MANUFACTURING PROCESSES** Packaging Assembly Technology, Wafer Thinning, Dicing, Die Attach, Wire bonding, Flip Chip process, Flux Cleaning, Underfill, Encapsulation, Laser Marking, Solder Ball Attach, Reflow, Singulation, IC Packaging Toolsets & equipment operation, clean room operations	8
Unit 2	**SEMICONDUCTOR COMPONENT AND PACKAGE TEST** Overview of Testing methodologies, components tested & their characteristics, Challenges in testing, Types of Testers (Automated test Equipment & Benchtop Testers), Components & Subsystems of Testers, Principles of Functional Testing, Parametric/ Boundary Scan /In-Circuit Test/ Flying Probe Test, Test Data Analysis, Design for Testability & Tester Calibration & Maintenance, Future Trends	10
Unit 3	**ELECTRICAL AND PHYSICAL FAILURE ANALYSIS** Package failure modes, Failure detection mechanisms, Failure analysis tools, Test programs debugging, Data Analytics, ESD & EMI Management	8
Unit 4	**SEMICONDUCTOR PACKAGE MATERIALS AND QUALIFICATION** Reliability testing & qualification- MST/MSL, TC/TS, HAST & uHAST, Mold Compounds (Moldability), Underfill Materials, Die Attach Adhesives & Films, Substrate Technology, Bonding Wire, Solder & Dielectric materials	8
Unit 5	**INDUSTRIAL QUALITY AND STATISTICAL PROCESS CONTROL** Quality Control Plan (QCP) & Quality Management System (QMS), Incoming Material Inspection, In-Line Quality, Measurement System Analysis, Statistical analysis methods, Statistical Process Control (SPC), Fault Detection Control (FDC), Run-to-Run Control (R2R), Auto Defect Classification (ADC), Data Analytics, Machine Communication Protocol and System Integration	8

Course Outcomes: By the end of this course, the students will be able to	
1	Comprehend the manufacturing process of various semiconductor packages.
2	Describe various package materials, their testing and failure analysis.
3	Explain the package qualification methods and industrial quality management for the same.
4	Explain EMI and ESD effects, test program analysis and statistical process control of package manufacturing.

Suggested Books:

Text Book		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Semiconductor Packaging: Materials interaction and reliability, Andrea Chen and R. Yu Lo, CRC	2012
2	Semiconductor Manufacturing, H. Geng, TMH	Latest edition
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Gary S. May, Costas J. Spanos, Fundamentals of Semiconductor Manufacturing and Process Control (Wiley - IEEE)	2006
2	Semiconductor advanced packaging, John H. Lau, Springer	2021

Equivalent MOOCs courses:

S.No.	**Course Links**	**Offered by**
1	Electronic Manufacturing and Packaging https://nptel.ac.in/courses/112105267	NPTEL
2	Intro to Electronic Packaging https://ep.jhu.edu/courses/525607-intro-to-electronic-packaging/	Johns Hopkins University, United States

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

Course Name	**:**	**NEURAL NETWORKS**
Course ID	**:**	**ECO104**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives

Students should be able-

- To explore the field of Neural Networks and relate the human neural system to the digital world.
- To explore the computational and dynamical systems using Neural Networks.
- To apply the machine and deep learning algorithms to various applications.
- To explore emerging trends and technologies in Neural Networks.

Total No. of lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**OVERVIEW OF NEURAL NETWORK:** Introduction to Artificial Neural Networks (ANN), Models of a Neuron, Network structure Error–correction learning, Feed-forward Network Functions, Single neuron/ Perceptron networks: Network Training, Gradient descent optimization, Multilayer Perceptron.	10
Unit 2	**NEURAL NETWORK-BASED RULES & ALGORITHMS:** Simple Associative Networks- Unsupervised Hebb Rule- Hebb Rule with Decay- Instar Rule-Outstar Rule- Kohonen Rule, Adaline Network- Madaline Network - Mean Square Error- LMS Algorithm- Back Propagation Neural networks – Hopfield Networks.	10
Unit 3	**INTRODUCTION TO DEEP LEARNING:** Deep generative models, Deep directed networks, Deep belief networks, Deep neural networks, Deep auto-encoders, and Applications of deep networks.	8
Unit 4	**MACHINE LEARNING:** Types of machine learning, Supervised learning, Unsupervised learning, basic concepts in machine learning, K Nearest Neighbours. Kernels, Kernel functions and Dimensionality Reduction: Subset Selection, Principal Component Analysis (PCA).	8
Unit 5	**NEURAL CONTROL APPLICATIONS:** Pattern recognition, Object recognition, Pattern classification, Supervised vs Unsupervised Classification, Natural Language Processing.	6

Course Outcomes: By the end of this course, the students will be able to:	
1.	Illustrate the fundamental areas of artificial neural networks.
2.	Acquire the knowledge of different machine learning techniques.
3.	Apply different machine-learning techniques to solve real-time problems.
4.	Model different architectures of Neural Networks.

Textbooks:		
Sr. No.	**Name of Book/Authors/Publisher**	**Year Of Publication /Reprint**
1.	Fundamentals of Neural Networks Architectures, Algorithms, and Applications by Laurene Fausett	2004
2.	Introduction to Deep Learning: From Logical Calculus to Artificial Intelligence by Sandro Skansi, 1st Edition, Springer	2018
Reference Books		
Sr. No.	**Name of Book/Authors/Publisher**	**Year Of Publication /Reprint**
1.	Neural network design by Hagan Demuth Beale, PWS publishing company	1995
2.	Neural Networks-Algorithms, applications and programming techniques by J.A. Freeman and D.M. Skapura, Addison Wesley	1991
3.	Neural Networks - A classroom approach by Satish Kumar, Tata McGraw-Hill Publishing Company Limited	2004
4.	Machine Learning by Tom M. Mitchell, McGraw Hill Education, India	2013
5.	Research and review papers in specific area.	

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Neural Networks and Applications by Prof. Somnath Sengupta, IIT Kharagpur https://nptel.ac.in/courses/117105084	NPTEL
2	NOC: Deep Learning- Part 1 by Prof. Sudarshan Iyengar, Prof. Sanatan Sukhija, IIT Madras, https://nptel.ac.in/courses/106106184	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO 2**
CO1	**H**	**M**	**M**						**H**				**H**	**M**
CO2	**H**	**M**	**M**		**M**				**H**				**M**	**H**
CO3	**H**	**H**	**H**	**H**	**M**				**H**				**M**	**H**
CO4	**H**	**H**	**H**	**H**					**H**				**H**	**M**

MINOR SPECIALIZATION COURSES

Course Name	**:**	**ANALOG AND DIGITAL ELECTRONICS**
Course ID	**:**	**ECM101**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:

Student should be able-

- To gain knowledge about the construction, operation, characteristics, biasing, and applications of BJTs and FETs.
- To explore the working and applications of operational amplifiers.
- To develop a comprehensive understanding of the applications of logic gates, and design various combinational circuits for practical applications.
- To develop a comprehensive understanding of various sequential circuits.

Lecture wise breakup		**No. of Lectures**
Unit 1	**BIPOLAR JUNCTION TRANSISTORS & FIELD EFFECT TRANSISTORS** Review of BJT and MOS transistor operation and characteristics, Transistor as an amplifier, Transistor biasing, Frequency Response of single stage CE amplifier, Metal oxide semiconductor field effect transistor: Ideal MOS Capacitor, Threshold Voltage, Body effect, Small-Signal Model, FET/MOSFET; Biasing and Design of FET/MOSFET (CS, CG, and CD) Amplifiers, introduction to feedback amplifiers and oscillators.	12
Unit 2	**OPERATIONAL AMPLIFIERS** Block diagram of a typical Opamp, Ideal Opamp, Open loop Opamp configurations, Opamp Characteristics, closed loop Opamp configurations, voltage series feedback or non-inverting amplifier, Voltage shunt feedback or inverting amplifier, summing scaling and averaging amplifiers, Subtractor, voltage to current converter, current to voltage converter, Integrator, Differentiator, Comparator.	10
Unit 3	**DIGITAL FUNDAMENTALS AND COMBINATIONAL CIRCUITS** Minimization techniques**:** Sum of Products and Products of Sum forms, Minterms & Maxterms, Karnaugh Map for two, three, four five and six variables, Combinational circuit design: Half adder, full adder, subtractor, BCD adder, comparator, code converter, encoder, decoder, multiplexer, demultiplexer, parity detector and generator	10
Unit 4	**SEQUENTIAL CIRCUITS** 1-bit memory cell, clocked and unclocked flip flops, S-R Flip flop, D flip flop, JK Flip flop, T flip flop, edge triggered flip flop, race around condition, Master slave flip flop, Ripple counter, design of Mod-N ripple counter, synchronous counter, decade counter, serial in serial out shift register, serial in parallel out shift register, parallel in serial out shift register and parallel in parallel out shift register, bidirectional shift register, universal shift register.	10

Course Outcomes: By the end of this course the students will be able to	
1	Describe and analyze the operation of BJTs and FETs.

2	Explain the basic building blocks of operational amplifier, their functioning and demonstrate their applications.
3	Design and implement various combinational circuits such as adder, subtractor, multiplexer, etc.
4	Design and analyze various sequential circuits.
5	Simulate and verify the functioning of the devices and circuits studied in the course.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	Integrated Electronics, Millman & Halkias, TMH.	2008
2.	Electronics Devices & Circuit Theory, RL Boylestead & L Nashelsky, PHI	2009
3.	Circuits and Networks: Analysis and Synthesis, Sudhakar and Shyam Mohan, TMH	2009
Reference books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	Electronics Circuit Analysis and Design, Donald A. Neamen, Tata McGraw Hill	2008
2.	Digital Design by Morris Mano, Pearson, 6th edition	2018
3.	Digital principles and Applications, by Malvino Leach, TMH	2011

List of Experiments:		**No. of turns**
1.	Verification of electrical circuit problems using Thevenin's, Norton's, and Superposition theorem.	2
2.	Perform the current-voltage characteristics of the pn-junction diode in forward and reverse-biased conditions.	1
3.	Study the switching behavior of the pn-junction diode.	1
4.	Study the input and output characteristics of an NPN Bipolar Junction Transistor (BJT) in Common-base and Common-emitter configurations.	2
5.	To Simulate and implement the working of OPAMP as a summing and difference amplifier.	1
6.	To Simulate and implement the working of OPAMP as an integrator & differentiator.	2
7.	To Simulate and implement the working of active and passive low pass filters and observe the frequency response using OPAMP.	1
8.	Implementation of various arithmetic circuits (4-bit parallel adder, combined adder, subtractor, multiplier, BCD adder)	2
9.	Implementation and simulation of synchronous sequential circuits like Flip-flops, registers and counters.	2

Sr. No.	Course Links	Offered by
1	Digital electronic circuits by Goutam Saha, IIT Kharagpur https://archive.nptel.ac.in/courses/108/105/108105132/	NPTEL
2	ANALOG ELECTRONIC CIRCUITS, IIT Delhi Prof. S.C. Dutta Roy https://nptel.ac.in/courses/108102095	NPTEL

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

Course Name	**:**	**CMOS Digital VLSI Design** *(Pre-requisites: Digital Logic Design and Electronic devices and circuits)*
Course ID	**:**	**ECM102**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:

Students should be able -

- To explain the scaling effects for MOSFET.
- To analyze the static and dynamic power dissipation in CMOS circuits.
- To design combinational and sequential CMOS circuits.
- To describe the effect of interconnects on crosstalk and delay.
- To explain different types of semiconductor memories.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**MOSFET SCALING AND ITS EFFECTS:** MOSFET Short Channel Effects, Geometric Scaling Theory and its effects– Full- Voltage Scaling, Constant Voltage Scaling.	4
Unit 2	**DESIGN FLOW AND CMOS INTEGRATED CIRCUITS LAYOUT:** Introduction to ASIC and SoC, Overview of ASIC flow, functional verification, RTL-GATE level synthesis, synthesis optimization techniques, pre-layout timing verification, static timing analysis, floor-planning, placement and routing, extraction, post-layout timing verification, extraction. CMOS Process flow, Stick Diagram and Layout – MOSFET Dimensions, Design Rules, Latch-up.	7
Unit 3	**CMOS INVERTERS:** CMOS Inverter, switching threshold and noise margin and their evaluation, static and dynamic behavior, switching characteristics- delay time calculation, static and dynamic power dissipation, techniques to reduce the power dissipation, energy and energy-delay calculations, Interconnects: Resistance, Capacitance and inductance Estimation, Delay and crosstalk	10
Unit 4	**CMOS COMBINATIONAL LOGIC GATES:** Complementary CMOS, Ratioed logic, Pass Transistors logic, Transmission Gate, CVSL, Dynamic logic: basic principle, Speed and Power Dissipation of Dynamic Logic, Issues in Dynamic Design, Cascading Dynamic Gates, NORA-CMOS-A Logic Style for Pipelined Structures	8
Unit 5	**SEQUENTIAL MOS LOGIC CIRCUITS:** Behavior of Bistable Elements, SR latch circuits, Clocked latch and Flip-flop Circuits, CMOS D-latch and Edge triggered FF, Dynamic Transmission-Gate Edge- triggered Registers. Clocks skew.	8
Unit 6	**SEMICONDUCTOR MEMORIES:** Non-volatile and volatile memory devices, flash memories, SRAM Cell Design, Differential Sense Amplifiers, DRAM Design, Memory peripheral circuitry, power dissipation in memories	5
Unit 7	**CASE STUDY:** Static timing analysis from cadence e-learning resources	

List of Experiments:		No. of Turns
1	Familiarization with simulation software for schematic, layout entry and circuit simulation	2
2	Perform the DC analysis of an n-channel MOSFET with W/L = 1.4µm/ 0.35µm at 180 nm technology node and plot its transfer characteristics and output characteristics.	2
3	Design a symmetric CMOS inverter with a load capacitance of 1 pF: c. Perform its transient analysis. d. Calculate and verify the rise time, fall time and propagation delay.	2
4	Design a symmetric CMOS inverter having W/L=1µm/ 0.18µm: c. Draw its layout d. Perform the post-layout simulations and compare them with the schematic for C_L= 2 pF	2
5	Design and verify a 2-input CMOS NAND and NOR gates that can drive a load capacitance of 1pF. Calculate and verify it's rise time, fall time and propagation delay.	2
6	Design and plot the characteristics of a positive and negative SR latch	1
7	Design and plot the characteristics of a positive and negative edge-triggered register	1
8	Design a 6T SRAM cell and perform its read-and-write operation	2

Course Outcomes: By the end of this course, the students will be able to	
1	Describe the scaling effects on MOS devices.
2	Analyze the static and dynamic power dissipation in CMOS circuits.
3	Identify the characteristics of CMOS circuits and design combinational and sequential circuits.
4	Classify the various semiconductor memories and analyze the delay and noise effect of interconnects.
5	Design and analyze the layout and schematics of various digital VLSI circuits using CAD tools.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Digital Integrated Circuits – A Design Perspective, J.M. Rabaey, A.P. Chandrakasen and B. Nikolic, Pearson Education 2nd ed.	Latest edition
2	CMOS Digital Integrated Circuits – Analysis and Design, S. Kang and Y. Leblebici, Tata McGraw Hill 3rd ed.	2008
Reference Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	CMOS VLSI Design: A Circuits and Systems Perspective, N.H.E. Weste and K. Eshraghian, Addision Wesley 2nd ed.	1998
2	CMOS Circuit Design, Layout and Simulation, R.J. Baker, H. W. Lee, and D. E. Boyce, Wiley - IEEE Press 2nd ed	2004

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
	CMOS Digital VLSI Design by Prof. Sudeb Dasgupta, IIT Roorkee https://archive.nptel.ac.in/courses/108/107/108107129/	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	**H**	**H**	**H**						**M**				**H**	**H**
CO2	**H**	**H**	**H**						**M**				**H**	**H**
CO3	**H**	**H**	**H**						**M**				**H**	**H**
CO4	**H**	**H**	**H**						**M**				**H**	**H**
CO5	**H**	**H**	**H**	**H**	**H**				**M**	**M**		**L**	**H**	**H**

Course Name	**:**	**COMMUNICATION SYSTEMS**
Course ID	**:**	**ECM103**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:

Students should be able-

- To comprehend the concepts of the random process and noise cancellation in communication systems.
- To explore the fundamentals of communication systems, including modulation types, radio receivers, and pulse communication.
- To explore modulation techniques used in digital communication.
- To acquire knowledge of source coding theorems, channel coding theorems and error control coding techniques.
- To explore various advanced communication technologies.

Total No. of Lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**RANDOM PROCESSES and NOISE MODELS** Random process, correlation and power spectrum of random signals, random signals through linear systems, Gaussian random process and white noise: Shot noise and thermal noise, Noise figure and noise temperature of a 2-port network, system noise cancellation	6
Unit 2	**ANALOG COMMUNICATION** Introduction to Communication Systems: Block diagram, Need for Modulation, Frequency band allocation, Theory of different types of modulation: Amplitude Modulation (AM), Frequency Modulation (FM), Phase Modulation (PM), Elements of radio receivers, Pulse Communication, Sampling theorem, Pulse Amplitude Modulation (PAM), Pulse Width Modulation (PTM), Pulse Position Modulation (PPM), Pulse Code Modulation (PCM)	10
Unit 3	**DIGITAL COMMUNICATION** Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK): BPSK and QPSK, MSK, Differential phase shift keying (DPSK), Quadrature Amplitude Modulation (QAM), Bandwidth Efficiency, Comparison of Various Digital Communication System (ASK, FSK, PSK, QAM).	8
Unit 4	**SOURCE AND ERROR CONTROL CODING** Entropy, Mutual Information, Source Encoding Theorem, Shannon Fanon Coding, Huffman Coding, Channel Capacity, Channel Coding Theorem, Error Control Coding, Linear Block Codes, Cyclic Codes, Error Detection and Correction Techniques	8
Unit 5	**OVERVIEW OF ADVANCED COMMUNICATION TECHNOLOGIES**	

	Overview of Mobile & Cellular communication, Optical Communication, Satellite & Radar communication, GSM, CDMA, Introduction to 5G & 6G communication technologies	10

List of Experiments		**No. of Turns**
1.	To implement modulation and demodulation of Double sideband modulation with carrier and double sideband modulation-suppressed carrier (DSB-SC)	2
2.	To simulate single-sideband modulation (SSB) and demodulation	1
3.	To simulate phase and frequency modulation and demodulation	2
4.	To implement modulation and demodulation of pulse amplitude modulation (PAM), pulse width modulation (PWM), and pulse position modulation (PPM)	2
5.	To implement delta modulation and adaptive delta modulation	1
6.	To simulate the modulation of amplitude shift keying (ASK), frequency shift keying (FSK)	2
7.	To implement modulation of differential phase shift keying modulation (DPSK)	2
8.	Case studies on modulation and multiplexing schemes in 5G and beyond	2

Course Outcomes: By the end of this course, the students will be able to	
1.	Analyze the concept of random variables and random processes.
2.	Describe the block diagram and modulation techniques for analog communication systems.
3.	Explain the block diagram and modulation techniques for digital communication systems.
4.	Discuss and compare the various types of codes used for error detection and correction.
5.	Develop an understanding of modulation schemes by conducting experiments /simulations.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	Simon Haykin, “Communication Systems”, 4th Edition, John Wiley & Sons	2004
2.	H.Taub, D L Schilling and G Saha, “Principles of Communication”, 3rd Edition, Pearson Education	2007
Reference books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	B. P.Lathi, “Modern Analog and Digital Communication Systems”, 3rd Edition, Oxford University Press	2007
2.	Blake, “Electronic Communication Systems”, Thomson Delmar Publications	2002
3.	Rappaport T.S, "Wireless Communications: Principles and Practice", 2nd Edition, Pearson Education	2007

Equivalent MOOCs courses

Sr. No.	Course Links	Offered by
1	Analog communication by Prof. Goutam Das, IIT Kharagpur https://onlinecourses.nptel.ac.in/noc21_ee74/preview	NPTEL
2	Digital Communication by Prof. Bikash Kumar Dey, IIT Bombay https://nptel.ac.in/courses/117101051	NPTEL

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

Course Name	**:**	**MICROCONTROLLERS AND THEIR APPLICATIONS**
Course ID	**:**	**ECM104**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:

Students should be able-

- To describe the architecture and functionality of 8051 microcontrollers.
- To analyze the I/O port programming and interfacing techniques of the 8051 microcontroller.
- To explore the hardware and software interrupts associated with microcontrollers.
- To analyze interfacing of PIC microcontroller and develop programs for the various applications of microcontrollers.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**8051 MICRO CONTROLLER:** Architecture, Pin configuration, SFRs, Memory, 8051 Addressing modes, Introduction to 8051 assembly language programming: JUMP, LOOP and CALL instructions, Arithmetic instructions: Unsigned addition and subtraction, unsigned multiplications and Division, signed number concepts and arithmetic operations, Logic and Compare instructions, BCD and ASCII Application Programs. Role of Assembler.	12
Unit 2	**I/O PORT PROGRAMMING** Single-bit instruction programming, Single-bit operations with CY, Reading Input Pins vs. port latch, Programming 8051 timers, counter-programming.	6
Unit 3	**INTERFACING of 8051** LCD & Keyboard Interfacing, ADC, DAC and Sensor Interfacing, 8051 connections to RS 232, 8051 serial communications Programming.	6
Unit 4	**INTERRUPTS** Programming Timer Interrupts, Programming External Hardware Interrupts, Programming the Serial Communication Interrupts, Interrupt Priority in the 8051.	4
Unit 5	**PIC18F FAMILY** The architecture of PIC 18F Microcontroller, PIC18F instructions and assembly language, PIC18F programming model, instruction set, and instruction format. Data copy, arithmetic, branch, logical, bit manipulation and multiply-divide instructions. Stacks, subroutines and macros. Role of Assembler, Input/Output ports and interfacing: PIC18 I/O ports and interfacing with peripherals.	14

List of Experiments:		**No. of Turns**
1.	Write an assembly language program to transfer data between specified memory locations.	**1**
2.	Write an assembly language program to find the largest number from a series.	**1**

3.	Write an assembly language program to find addition, subtraction, multiplication, and division.	**2**
4.	Write an assembly language program to find 16-bit addition from internal and external memory.	**1**
5.	Write an assembly language program to find the square of a number.	**1**
6.	Write an assembly language program for toggling the LED connected to one of the port pins of 8051.	**2**
7.	Write an assembly language program for displaying the decimal numbers in a 7-segment display.	**2**
8.	Write an assembly language program to generate a square wave using 8051.	**2**
9.	Write an assembly language program to interface the EM relay with 8051.	**2**

Course Outcomes: By the end of this course, students will be able to:	
1	Explain the architecture and functioning of the 8051 microcontroller.
2	Explore the instruction set of 8051 and develop programs based on it.
3	Develop an understanding of interfacing, I/O communication, and interrupts of the 8051 microcontroller.
4	Explain the architecture, functioning, and instruction set of the PIC microcontroller.
5	Write assembly language programs for various operations and interfacing etc. for microcontroller.

Textbooks:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	The 8051 Microcontroller and Embedded System by Muhammad Ali Mazidi, Janice Gillespie Mazidi, Pearson Education Publications.	2007
Reference books:		
1	Fundamentals of Microcontrollers and Applications in Embedded Systems (with the PIC18 Microcontroller Family), Ramesh Gaonkar, Penram International Publishing, 2007 edition.	2007

Equivalent MOOCs courses

Sr. No.	**Course Links**	**Offered by**
1	Microprocessors and Interfacing https://archive.nptel.ac.in/noc/courses/noc20/SEM1/noc20-ee11/	NPTEL
2	Microprocessors and Microcontrollers https://archive.nptel.ac.in/courses/106/108/106108100/	NPTEL

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