NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

CURRICULUM &

SYLLABUS OF

BACHELOR OF TECHNOLOGY IN ELECTRONICS AND COMMUNICATION ENGINEERING

2023 ONWARD ADMISSION BATCH

V0:

First Year Curriculum Recommended by members of UGAC	19.08.2023
First Year Curriculum Approved by the Chairman, Senate	19.08.2023
First Year Curriculum & Syllabus ratified in the 71st Senate meeting (Item No. 71.5(b))	18.12.2023
Entire Curriculum and Syllabus Recommended by UGAC	09.12.2024
Entire Curriculum and Syllabus Approved by the 73rd Senate (Item No. 73.8)	23.03.2025

CURRICULUM

GROUP – 1

FIRST SEMESTER

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics - I	3	1	0	4	4
2	CSC01	Computer Programming	2	1	0	3	3
3	XEC01	Engineering Mechanics	2	1	0	3	3
4	XEC02	Basic Electrical and Electronics Engineering	3	0	0	3	3
5	ESC01	Ecology and Environment	2	0	0	2	2
6	CYC01	Engineering Chemistry	3	0	0	3	3
7	CSS51	Computer Programming Laboratory	0	0	3	2	3
8	XES52	Basic Electrical and Electronics Engineering Laboratory	0	0	3	2	3
9	CYS51	Engineering Chemistry Laboratory	0	0	2	1	2
		TOTAL	**15**	**3**	**8**	**23**	**26**

SECOND SEMESTER

Semester - II							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC02	Mathematics - II	3	1	0	4	4
2	CSC02	Data Structure and Algorithms	2	1	0	3	3
3	PHC01	Engineering Physics	2	1	0	3	3
4	HSC01	Professional Communication	2	0	2	3	4
5	CSS52	Data Structure and Algorithms Laboratory	0	0	3	2	3
6	XES51	Engineering Graphics	0	1	3	3	4
7	PHS51	Engineering Physics Laboratory	0	0	2	1	2
8	XXS51	Extra Academic Activities	0	0	2	1	2
		TOTAL	9	4	12	20	25

GROUP – 2

FIRST SEMESTER

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics - I	3	1	0	4	4
2	CSC01	Computer Programming	2	1	0	3	3
3	XEC01	Engineering Mechanics	2	1	0	3	3
4	PHC01	Engineering Physics	2	1	0	3	3
5	HSC01	Professional Communication	2	0	2	3	4
6	CSS51	Computer Programming Laboratory	0	0	3	2	3
7	XES51	Engineering Graphics	0	1	3	3	4
8	PHS51	Engineering Physics Laboratory	0	0	2	1	2
9	XXS51	Extra Academic Activities	0	0	2	1	2
		TOTAL	**11**	**5**	**12**	**23**	**28**

SECOND SEMESTER

Semester - II							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC02	Mathematics - II	3	1	0	4	4
2	CSC02	Data Structure and Algorithms	2	1	0	3	3
3	XEC02	Basic Electrical and Electronics Engineering	3	0	0	3	3
4	ESC01	Ecology and Environment	2	0	0	2	2
5	CYC01	Engineering Chemistry	3	0	0	3	3
6	CYS51	Engineering Chemistry Laboratory	0	0	2	1	2
7	CSS52	Data Structure and Algorithms Laboratory	0	0	3	2	3
8	XES52	Basic Electrical and Electronics Engineering Laboratory	0	0	3	2	3
		TOTAL	**13**	**2**	**8**	**20**	**23**

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Semester - III

Sl.	Code	Subject	L	T	S	C	H
1	MAC331	Mathematics - III	3	1	0	4	4
2	ECC301	Network Analysis and Synthesis	3	1	0	4	4
3	ECC302	Semiconductor Devices and Technology	3	0	0	3	3
4	ECC303	Signals and Systems	3	1	0	4	4
5	ECC304	Digital Circuits and Systems	3	1	0	4	4
6	ECS351	Network Analysis and Synthesis Laboratory	0	0	3	2	3
7	ECS352	Semiconductor Devices Laboratory	0	0	3	2	3
8	ECS353	Digital Circuits and Systems Laboratory	0	0	3	2	3
9	XXS381	Co-curricular Activities - III (Optional)	0	0	0	0	0
		TOTAL	**15**	**4**	**9**	**25**	**28**
Semester - IV							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	ECC401	Communication Systems I	3	1	0	4	4
2	ECC402	Digital Signal Processing	3	1	0	4	4
3	ECC403	Electromagnetic Theory and Transmission Lines	3	1	0	4	4
4	EEC431	Control Systems	2	1	0	3	3
5	ECC404	Microelectronic Circuits	3	1	0	4	4
6	ECS451	Communication Systems Laboratory I	0	0	3	2	3
7	ECS452	Simulation Laboratory	0	0	3	2	3
8	ECS453	Microelectronic Circuits Laboratory	0	0	3	2	3
9	XXS481	Co-curricular Activities - IV (Optional)	0	0	0	0	0
		TOTAL	**14**	**5**	**9**	**25**	**28**
Semester - V							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	ECC501	Communication Systems II	3	1	0	4	4
2	ECC502	Computer Organization and Architecture	3	0	0	3	3
3	ECC503	Microcontrollers and Embedded Systems	3	1	0	4	4
4	ECE510-	Professional Elective Paper 1	3	0	0	3	3
5	ECC504	Artificial Intelligence and Machine Learning	3	0	0	3	3
6	ECS551	Communication Systems Laboratory II	0	0	3	2	3
7	ECS552	Digital Signal Processing Laboratory	0	0	3	2	3
8	ECS553	Microcontrollers and Embedded Systems Laboratory	0	0	3	2	3
9	XXS581	Co-curricular Activities - V (Optional)	0	0	0	0	0
		TOTAL	**15**	**2**	**9**	**23**	**26**

Semester - VI							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	HSC631	Economics and Accountancy	3	0	0	3	3
2	ECC601	VLSI Design	3	1	0	4	4
3	ECC602	Microwave and Antenna Engineering	3	1	0	4	4
4	ECE610-	Professional Elective Paper 2	3	0	0	3	3
6	ECE610-	Professional Elective Paper 3	3	0	0	3	3
7	ECS651	VLSI Design Laboratory	0	0	3	2	3
8	ECS652	Microwave and mm Wave Laboratory	0	0	3	2	3
9	ECS653	Capstone Project – I	0	0	3	2	3
10	XXS681	Co-curricular Activities - VI (Optional)	0	0	0	0	0
		TOTAL	**15**	**2**	**9**	**23**	**26**
Semester - VII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MSC731	Professional Ethics for Engineers &/ Principles of Management	3	0	0	3	3
2	ECE710-	Professional Elective Paper 4	3	0	0	3	3
3	ECE710-	Professional Elective Paper 5	3	0	0	3	3
5	YYO74*	Open Elective 1	3	0	0	3	3
6	ECS751	Electronic System Design Laboratory	0	0	3	2	3
7	ECS752	Summer Internship and Seminar	0	0	2	1	2
8	ECS753	Capstone Project - II	0	0	6	4	6
		TOTAL	**12**	**0**	**11**	**19**	**23**
Semester- VIII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	**S851 / **S852	Capstone Project – III / Industry Internship	0	0	12	6	12
3	**S853	Comprehensive Viva	0	0	0	1	0
		TOTAL	**0**	**0**	**12**	**7**	**12**

CREDIT UNIT OF THE PROGRAM:

Semester	**I + II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**TOTAL**
Credit Unit	43	25	25	23	23	19	7	165

Subject	L	T	S	C	H	Sc.	HSS	MA	Engg Core	Dep Core	Dep Elec	Open Elec	EAA
I + II	24	7	20	43	51	10	3	8	21	0	0	0	1
III	**15**	**4**	**9**	**25**	**28**	3	0	4	0	18	0	0	0
IV	**14**	**5**	**9**	**25**	**28**	0	0	0	3	22	0	0	0
V	**15**	**2**	**9**	**23**	**26**	0	0	0	3	17	3	0	0
VI	**15**	**2**	**9**	**23**	**26**	0	3	0	0	14	6	0	0
VII	**12**	**0**	**11**	**19**	**23**	0	2	0	1	7	6	3	0
VIII	**0**	**0**	**12**	**7**	**12**	0	0	0	1	6	0	0	0
Total	**95**	**20**	**79**	**165**	**194**	**13**	**8**	**12**	**29**	**84**	**15**	**3**	**1**
Total (in %)	**48.97**	**10.31**	**40.72**			**7.88**	**4.84**	**7.28**	**17.58**	**50.91**	**9.09**	**1.82**	**0.60**

DEPTH ELECTIVE COURSE BASKETS

THE STUDENTS PRIMARILY WILL OPT FROM THE DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER BY HIS/ HER OWN DEPARTMENT. HOWEVER, A STUDENT CAN OPT FOR DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED BY OTHER DEPARTMENT IN A PARTICULAR SEMESTER, WITH THE PERMISSION/ CONSENT FROM HIS/ HER HEAD OF THE DEPARTMENT AND THE CONCERNED TEACHER OF THAT SUBJECT.

5th Semester

	DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
ECE510	Object Oriented Programming
ECE511	Probability and Random Signal Theory
ECE512	Data Communication and Computer Networks
ECE513	Mobile Computing
ECE514	Optical Communication
ECE515	Measurement and Instrumentation
ECE516	Power Electronics
ECE517	Active Filter Design
ECE518	Nanoelectronics
ECE519	Mechatronics Systems
ECE520	Digital IC Design
ECE521	Statistical Signal Processing
ECE522	Biomedical Signal Processing
ECE523	Internet of Things (IoT) Technology
ECE524	Audio Signal Processing

6th Semester

	DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
ECE610	Detection and Estimation Theory
ECE611	Information Theory and Coding
ECE612	Analog IC Design
ECE613	FPGA Based Design
ECE614	MEMS and Microsystems Technology
ECE615	VLSI Process Technology
ECE616	ASIC Design using Verilog/VHDL
ECE617	RFID Technology and Applications
ECE618	Advanced Wireless Communication
ECE619	Digital Image Processing
ECE620	Advanced Semiconductor Devices
ECE621	Random Process
ECE622	Biostatistics in Network Analysis
ECE623	Biomedical Instrumentation
ECE624	Quantum Computing, Communication, and Security

7th Semester

	DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
ECE710	Statistical and Machine Learning Approaches for Network Analysis
ECE711	Mixed Signal IC Design
ECE712	Multidimensional Signal Image and Video Processing
ECE713	Satellite and Radar Engineering
ECE714	RF IC Design
ECE715	Low Power VLSI
ECE716	Advanced Antenna Synthesis
ECE717	mm-Wave and THz Communication
ECE718	DSP Architectures in VLSI
ECE719	VLSI Testing and Verification
ECE720	Machine Learning for Electronic Design Automation
ECE721	Embedded Machine Learning
ECE722	Deep Learning in Signal Processing
ECE723	MIMO Communication

DETAILED SYLLABUS

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC01	**MATHEMATICS - I**	PCR	3	1	0	4	4
Pre-requisites		Basic concepts of function, limit, differentiation and integration.					
Course Outcomes	• CO1: learn the fundamentals of differential calculus of single and several variables. • CO2: learn the basic concepts of convergence of infinite series. • CO3: understand the basic concepts of integral calculus along with its various applications. • CO4: acquire the theoretical knowledge of vector calculus and its engineering applications.						
Topics Covered	**Functions of Single Variable:** Review of limit, continuity and differentiability. Mean value theorems: Rolle's Theorem, Lagrange's Mean Value Theorem (MVT), Cauchy's MVT, Taylor's theorem, Taylor's and Maclaurin's series. (8) **Functions of several variables:** Limit, continuity and differentiability of functions of several variables, partial derivatives and their geometrical interpretation, derivatives of composite and implicit functions, derivatives of higher order and their commutativity, Homogeneous function, Euler's theorem and its converse, Exact differential, Jacobian, Taylor's & Maclaurin's series, Maxima and Minima, Necessary and sufficient condition for maxima and minima (no proof). (11) **Sequences and Series:** Real sequences and their convergence, Series of positive terms, Necessary and sufficient condition for convergence, p-series, geometric series, Comparison test, D Alembert's ratio test, Cauchy's root test, Alternating series, Leibnitz's rule, Absolute and conditional convergence. (6) **Integral Calculus:** Review of the idea of integration as a limit of a sum, Mean value theorems of integral calculus, Area and length in Cartesian and polar co-ordinates, Volume and surface area of solids of revolution in Cartesian and polar forms, Improper integrals and their convergence, Beta and Gamma functions. (12) **Multiple Integrals:** Evaluation of double and triple integrals, Change of order of integration, Change to better coordinates, Area and volume by double integration, Volume by triple integration. (10) **Vector Calculus:** Vector valued functions and its differentiability, Line integral, Surface integral, Volume integral, Gradient, Curl, Divergence, Green's theorem in the plane (including vector form), Stokes' theorem, Gauss's divergence theorem and their engineering applications. (9)						
Text Books, and/or reference material	**Text Books:** 1. Kreyszig, E., Advanced Engineering Mathematics: 10th edition, Wiley India Edition, 2010. 2. Murray, D.A., Differential and Integral Calculus, FB & C Limited, 2018. 3. Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2014. 4. Murray Spiegel, Schaum's Outline of Vector Analysis, .0waw ر oiwa ur liH warGcM ataT **Reference Books:** 1. Tom Apostal, Calculus-Vol-I & II, Wiley Student Edition, 2011. 2. Thomas and Finny: Calculus and Analytic Geometry, 11th Edition, Addison Wesley.						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	2	3	2	3	1	1	-	-	1	1	1	2
	CO2	2	3	2	3	-	1	-	-	1	1	2	2
	CO3	2	3	2	3	-	1	1	-	-	2	2	2
	CO4	3	3	2	3	1	1	-	1	-	2	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC01	**COMPUTER PROGRAMMING**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic knowledge of computer.		CT+MT+EA					
Course Outcomes		• CO1: To understand basics of computer programming, program flow, and programming constructs. • CO2: Develop concepts on basic and complex data types, conditional and iterative statements. • CO3: Exercise the concepts of user defined functions to solve real time problems. • CO4: Inscribe C programs that use Pointers to access arrays, strings and functions. • CO5: Exercise user defined data types including structures and unions to solve problems.					
Topics Covered		**Introduction to C**: Phases of developing a running computer program in C. (2L) Data types, size and values. Char, Unsigned and Signed data types. Number systems and representations. Constants, Overflow. (3L) Data concepts in C: Constants, Variables, Expressions, Operators, and operator precedence in C. (2L) Statements: Declarations, Input-Output Statements, Compound statements, Selection Statements. (2L) Conditions, Logical operators, Precedences. Repetitive statements, While construct, Do-while Construct, For construct. (3L) Arrays. Strings. Multidimensional arrays and matrices. (3L) **Pointers:** Pointer variables. Declaring and dereferencing pointer variables. Pointer Arithmetic. Examples. Accessing arrays through pointers. Pointer types, Pointers and strings. String operations in C. (6L) Dynamic memory allocation. (2L) **Modular Programming:** Functions: The prototype declaration, Function definition. (3L) Function call: Passing arguments to a function, by value, by reference. Scope of variable names. Recursive function calls, Tail recursion. (4L) Sorting problem: Sorting in arrays with an example of Bubble sort. Sorting in strings. (3L) Search problem: Linear search and binary search. (2L) **More Data-types in C:** Structures in C: Motivation, examples, declaration, and use. Operations on structures. Passing structures as function arguments. type defining					

	structures. (4L) File input-output in C. Streams. Input, output and error streams. Opening, closing and reading from files. Programming for command line arguments. (3L)
Text Books, and/or reference material	**Text Books:** 1. P. Deitel, H. Deitel. C How to Program. Pearson Education India, 7th Ed. 2. B. W. Kernighan, Dennis M. Ritchie. The C Programming. Prentice Hall Software Series, 2nd Ed. **Reference Books:** 1. P. Dey and M. Ghosh. Computer fundamentals and programming in C. Oxford press, 2013. 1. Y. Kanetkar. Let Us C. BPB Publications, Sixteenth edition, 2017.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC01	CO1	2	2	1	-	1	2	-	-	-	-	-	-
	CO2	3	2	1	-	1	1	1	-	-	-	-	-
	CO3	2	2	1	-	-	2	-	-	-	-	-	-
	CO4	3	2	2	-	-	1	-	-	-	-	-	-
	CO5	3	1	2	-	1	2	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XEC01	**ENGINEERING MECHANICS**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes		• CO1: Acquire knowledge of mechanics and ability to draw free body diagrams. • CO2: Apply knowledge of mechanics for solving special problems like truss and frame analysis. • CO3: Ability to calculate centroid, moments of inertia for various shapes. • CO4: Learn momentum and energy principles. • CO5: Knowledge on virtual Work Principle and its application					
Topics Covered		Engineering Mechanics; measurement and SI units. [1] Vectors and force as a vector; Resultant of a system of forces on a particle; free body diagram and conditions of equilibrium of a particle; problems on particles; equilibrium of particles in space. [2] Resultant of a system of forces and couples on a rigid body; conditions of equilibrium of a rigid body; free body diagrams of rigid bodies subjected to different types of constraints; simple space problems of rigid bodies. [4] Coefficients of static and kinetic friction; problems involving friction; theories of friction on square threaded power screw and flat belt. [5] Simple trusses; analysis of trusses by method of joints and method of sections. [5]					

	Centre of gravity and centre of mass; centroids of lines, curves and areas; first moment of area; second moment of area; polar moment of inertia; radius of gyration of an area; parallel axis theorem; mass moment of inertia. [4] Path, velocity, acceleration; rectilinear and curvilinear motion; motion of system of particles; introduction to the concept of plane kinematics of rigid bodies. [6] Newton's second law of motion; dynamic equilibrium and D'Alembert's principle; linear momentum; angular momentum; rectilinear and curvilinear motion; principles of work–energy and impulse–momentum; impact of system of particles; introduction to the concept of plane kinetics of rigid bodies. [12] Principle of Virtual Work, Solution of Problems on Mechanics using Principle of Virtual Work [3]
Text Books, and/or reference material	1) S P Timoshenko and D H Young, Engineering Mechanics, 5th Edition 2) J L Meriam and L G Kraige, Engineering Mechanics, 5th Edition, Wiley India 3) F P Beer and E R Johnston, Vector Mechanics for Engineers 4) I H Shames, Engineering Mechanics

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHC01	**Engineering Physics**	**PCR**	**2**	**1**	**0**	**3**	**3**
Pre-requisites:		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	• CO1: To realize and apply the fundamental concepts of physics such as superposition principle, simple harmonic motion to real world problems. • CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field. • CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization. • CO4: Acquire basic knowledge related to the working mechanism of lasers and signal propagation through optical fibers.						
Topics Covered	**Harmonic Oscillations** - Linear superposition principle, Superposition of two perpendicular oscillations having same and different frequencies and phases, Free, Damped and Forced vibrations, Equation of motion, Amplitude resonance, Velocity resonance, Quality factor, sharpness of resonance, [8]						

	Wave Motion: Longitudinal waves, Transverse waves, Wave equation, phase velocity and group velocity, Maxwell's equations, Electro-magnetic waves in free space. [3] **Introductory Quantum Mechanics** - Inadequacy of classical mechanics, Blackbody radiation, Planck's quantum hypothesis, de Broglie's hypothesis, Heisenberg's uncertainty principle and applications, Schrodinger's wave equation and applications to simple problems: Particle in a one-dimensional box, Simple harmonic oscillator, Tunnelling effect. [8] **Interference & Diffraction** - Huygens' principle, Young's experiment, Superposition of waves, Conditions of sustained Interference, Concepts of coherent sources, Interference by division of wavefront, Interference by division of amplitude with examples, The Michelson interferometer and some problems; Fraunhofer diffraction, Single slit, Multiple slits, Resolving power of grating. [13] **Polarisation** - Polarisation, Qualitative discussion on Plane, Circularly and elliptically polarized light, Malus law, Brewster's law, Double refraction (birefringence) - Ordinary and extra-ordinary rays, Optic axis etc.; Polaroid, Nicol prism, Retardation plates and analysis of polarized lights. [5] **Laser and Optical Fiber** - Spontaneous and stimulated emission of radiation, Population inversion, Einstein's A & B co-efficient, Optical resonator and pumping methods, He-Ne laser. Optical Fibre– Core and cladding, Total internal reflection, Calculation of numerical aperture and acceptance angle, Applications. [5]
Text Books, and/or reference material	**TEXT BOOKS**: 1. The Physics of Vibrations and Waves, H. John Pain, Willy and Sons 2. A Text Book of Oscillations and Waves, M. Goswami and S. Sahoo, Scitech Publications 3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill. **REFERENCE BOOKS**: 1. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press 2. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons 3. Fundamental of Optics, Jankins and White, McGraw-Hill 4. Optics, A. K. Ghatak, Tata McGraw-Hill 5. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill 6. Lasers and Non-linear Optics, B. B. Laud, New Age International Pvt Lt

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Code		(PCR) / Electives (PEL)	Lecture (L)	Tutoria l l (T)	Practical (P)	Total Hours	
CYC01	**Engineering Chemistry**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					

Course Outcomes	• CO1: Students will get the knowledge of fundamentals as well industrial applications of polymer, petroleum products, organometallic compounds and others. • CO2: Students will be able to elucidate the structure of different organic compounds and to analyze the structure-property correlation. • CO3: Students will be aware on the role played by different metals in biological systems and also the ecological impact of metals. • CO4: Students will be able to understand and analyze thermodynamical, kinetic as well as electrochemical aspects of chemical systems and apply the understanding in the technical field.
Topics Covered	**ORGANIC CHEMISTRY** i. **Polymer chemistry and polymer engineering:** Fundamental concept on polymer chemistry; synthesis and application of important polymers, Rubber and plastic materials; vulcanization, structure-property correlation: Concept of Molecular weight of polymer, Glass transition temperature. Engineered polymer: Thermally stable, flame retardant, Conducting polymer. (5L) ii. **Petroleum Engineering and oil refinery:** Origin of petroleum, separation principle and techniques of distillation of crude oil, thermal and catalytic cracking of petroleum, uses of different fractions, knocking, anti-knock compounds, octane number and cetane number. High octane and Aviation fuel. Bio-diesel. (3L) iii. **Structure elucidation of organic compounds by modern spectroscopic methods:** Application of UV-Visible (Lambert-Beers law), concept of chromophore, auxochrome, hypso-, hyper-, bathochromic, red shift. FT-IR spectroscopy and Mass spectroscopy (including instrumentation). (4L) **INORGANIC CHEMISTRY** i. **Coordination Chemistry:** Crystal Field Theory of octahedral and tetrahedral complexes, colour and magnetic properties, LMCT, MLCT, IVCT. Isomerism and stereochemistry.(5L) ii. **Bioinorganic Chemistry:** Metal ions in biological systems: Fe, Cu (2L) iii. **Industrial applicationof Organometallic complexes:** π-acid ligands, stabilization of metal low oxidation state and 18 electron rules, metal carbonyls and nitrosyls, metal-alkene complexes, Various catalytic cycles of industrial importance. (4L) iv. **Environmental Chemistry:** Metal toxicity (As, Hg, Pb and Cd) and its remediation (1L) **PHYSICAL CHEMISTRY** i. **Chemical Thermodynamics:** 2nd law of thermodynamics: Concept of thermodynamic engine (Carnotand reverse Carnot cycle), entropy, free energy. Temperature and pressure dependence of entropy and free energy. Change in phase: phase diagram of single component system. Cryogenics: Joule Thomson experiment. (5L) ii. **Chemical Kinetics:**Rate expression of Reversible reaction, parallel reaction,and Consecutive reaction with proper examples. Temp effect on reaction rate.(3L) iii. **Catalysis:** Types of catalysis, Rate expression for Catalysed reaction, Acid-base and Enzyme catalysis.(2L)

	iv. **Electrochemistry:**EMF, Nernst Equation, Application of electrochemistry in chemical processes. Electrochemical cell, Fuel cell, Li-ion battery (3L).
Text Books, and/or reference material	Suggested Text Books: (i) Physical Chemistry by P. Atkins, Oxford (ii) A guidebook to mechanism in Organic chemistry: Peter Sykes; Pearson Edu. (iii) Inorganic Chemistry Part-I & II, R. L. Dutta, The new book stall Suggested Reference Books: **Organic Chemistry**: (i) Basic stereochemistry of organic molecules: S. Sengupta; Oxford University press (ii) Engineering Chemistry: Wiley (iii) Elementary Organic Spectroscopy: William Kemp, ELBS with Macmillan **Inorganic Chemistry:** (i) Inorganic Chemistry: Principle structure and reactivity, J. E. Huheey, E. A. Keiter and R. L. Keiter, Pearson Education (ii) Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introductionand Guide, 2nd Edition, Wolfgang Kaim, Brigitte Schwederski, Axel Klein. (iii) Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford **Physical Chemistry:** (i) Physical Chemistry by G.W Castellan (ii) Physical Chemistry by P. C. Rakshit

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYC 01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ESC01	**Ecology and Environment**	PCR	2	0	0	2	2
Pre-requisites		Basic concepts of function, limit, differentiation and integration.					
Course Outcomes	• CO1: Understand the importance of environment and ecosystem. • CO2: Understand the fundamental aspect of pollutant trackingand its implementation in natural and anthropogenic pollution of air and water system. • CO3: Understand the scientific basis of local and as well as global issues. • CO4: Apply of knowledge to develop sustainable solution.						

Topics Covered	UNIT – I: INTRODUCTION (2) Multidisciplinary nature of Environmental Studies: Definition, Scope, and Importance. UNIT–II: FUNDAMENTALS OF ECOLOGY (9) Definition, Components of Environment; Fundamentals of Ecology and Ecosystem; Components and Classification of Ecosystem; Energy flow in Ecosystem: Tropic level, Food Chain, Food Web, Ecological Pyramid; Biogeochemical cycles: Carbon, Nitrogen, Sulphur, Phosphorus, and Water Cycle; Biosphere and Biodiversity; Conservation. UNIT–III: FUNDAMENTALS OF ENVIRONMENT (10) Environmental Pollution: Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Solid Wastes, and Natural hazards: Floods, earthquakes, cyclones, and landslides. Environmental Issues: Climate change and global warming; acid rain; and ozone layer depletion. Environment Quality: Ambient air quality standards, Water quality parameters and standards: pH, Turbidity, Hardness, Sulphate, Phosphates, Iron, Dissolved Oxygen, BOD, and COD. UNIT– IV: NATURAL RESOURCES (3) Mineral Resources, Energy Resources: Conventional and Non-Conventional. UNIT- V- GREEN TECHNOLOGY & ENVIRONMENTAL ETHICS (4) Sustainability: Carbon Sequestration, Green building practices, Green computing; Carrying capacity; and Environment Protection Acts/laws.
Text Books, and/or reference material	1. A Basic Course in Environmental Studies. Deswal & Deswal. Pub. Dhanpat Rai & Sons 2. Ecology. Odum. Pub. Oxford & IBH 3. Environmental Engineering. Peany et.al. Pub. McGraw Hill 4. A Text Book of Environmental Engg. Venugpal Rao. Pub. PHI 5. A Basic Course in Environmental Studies. Deswal & Deswal. Pub. Dhanpat Rai & Sons 6. Environmental Studies. Bharucha. Pub. University of Press 7. Environmental Chemistry and Pollution, S. S. Dara & D. D. Mishra, S. Chand Publishing

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSC01	**Professional Communication**	PCR	2	0	2	4	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					

Course Outcomes	• CO1: Learners will acquire linguistic proficiency in terms of improvement in their listening, speaking, reading, and writing skills. • CO2: Learners will acquire better communicative ability. • CO3: The course will help learners improve their social connectivity skill.
Topics Covered	Vocabulary 1. Word Formation, Use of Prefixes and Suffixes (1) 2. Synonyms, Antonyms (1) 3. Prefixes and Suffixes from Foreign Languages, Words from Foreign Languages (1) 4. Abbreviations and Acronyms (1) 5. Technical Vocabulary Grammar 1. Identifying Common Errors in Articles and Prepositions (1) 2. Common Errors in Noun-Pronoun Agreement and Subject-Verb Agreement (1) 3. Misplaced Modifiers and Tenses (1) 4. Redundancies and Clichés Reading 1. Reading and Its Importance, Techniques of Effective Reading (1) 2. Improving Comprehension Skills, Techniques for Good Comprehension (1) 3. Skimming and Scanning (1) 4. Comprehension, Intensive and Extensive Reading Writing 1. Sentence Structures, Phrases and Clauses, Punctuation (2) 2. Organising Principles of Paragraphs (2) 3. Formal Letters, Letters of Complaint, Requisition Letters, Job Application, and Résumé (2) 4. Nature and Style of Sensible Writing, Defining, Describing, Classifying, Providing Examples and Evidence (2) 5. Essay Writing (2) 6. Précis Writing (2) 7. Report Writing Oral Communication 1. Listening Comprehension (4) 2. Pronunciation, Intonation, Stress, and Rhythm (4) 3. Communication at the Workplace (4) 4. Everyday Conversation (4) 5. Group Discussion (4) 6. Interviews (4) 7. Formal Presentations (4)
Text Books, and/or reference material	**Text Book:** 1. English for Engineers –Sudharshana & Savitha (Cambridge UP) **Reference Books:** 2. *English*—Kulbhushan Kumar (Khanna Book Publishing) *Remedial English Grammar*—F. T. Wood (Macmillan)

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
HSC01	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC02	**MATHEMATICS - II**	PCR	3	0	1	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basic concepts of set theory, differential equations, and probability.		CT+EA					

Course Outcomes	• CO1: learn the basic concepts of linear algebra and be able to apply the same to solve various engineering problems. • CO2: understand fundamentals of ordinary differential equations and their applications. • CO3: acquire the theoretical knowledge of Fourier Series, Fourier & Laplace transforms, and learn about their applications. • CO4: learn the basic concepts of probability theory.
Topics Covered	**Algebraic Structures** (3L) Introduction to algebraic structures: groups, subgroups, rings, subrings, integral domains, and fields. **Linear Algebra** (15L) Vector spaces over a field, concepts of linear dependence and independence, linear span, basis and dimension of finite-dimensional vector spaces. Elementary row and column operations, matrix rank, solution of systems of linear equations (both homogeneous and non-homogeneous). Eigenvalues and eigenvectors, characteristic polynomial, statement of the Cayley-Hamilton theorem, and matrix diagonalization. **Ordinary Differential Equations (ODEs)** (18L) Review of first-order ODEs and the statement of Picard's theorem. First-order, first-degree ODEs: exact equations and integrating factors. Higher-degree first-order ODEs: equations solvable for xxx, yyy, and Clairaut's equation with singular solutions. Homogeneous and non-homogeneous linear ODEs with constant and variable (Euler–Cauchy type) coefficients. Linear dependence of solutions, Wronskian determinant, solutions of simultaneous ODEs. Introduction to nonlinear ODEs and phase plane analysis. **Fourier Series** (4L) Piecewise smooth and periodic functions, Fourier series on a given interval, Dirichlet conditions, convergence of Fourier series, Fourier sine and cosine series, and the complex form of Fourier series. **Fourier Transforms** (7L) Statement of the Fourier integral theorem, various forms of Fourier integrals, Fourier transform and its inverse, properties of Fourier transforms, and convolution. **Laplace Transforms** (4L) Laplace transform and its properties, inverse Laplace transform, convolution theorem, and applications to solving ODEs. **Probability** Random variables and probability distributions.

	Binomial, Poisson, Uniform and Normal distributions.
Text Books, and/or reference material	**Text Books:** 1. Kreyszig, E., Advanced Engineering Mathematics: 10th edition, Wiley India Edition (2010). 2. Strang, G., Linear algebra and its applications (4th Edition), Thomson (2006). 3. Murray, D.A., Introductory Course in Differential Equations, Khosla Publishing House (2021). 4. Debnath, L., Integral Transforms and Their Applications, CRC Press (1995). 5. Baisnab, A.P., Jas, M., Elements of Probability and Statistics, McGraw Hill Education (2017). **Reference Books:** 1. Kumaresan, S., Linear algebra - A Geometric approach, Chaukhamba Auriyantaliya (2017). 2. Ross, S.L., Differential Equations, 3rd Edition, Wiley Student Edition (2017). 3. Shivamoggi, A., Integral Transforms for Engineers, PHI (2003). Grinstead, C.M., Snell, J.L., Introduction to probability, American Mathematical Society (2012).

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC02	CO1	3	3	2	1	2	-	2	-	-	-	1	2
	CO2	3	3	2	2	2	-	2	-	-	1	-	2
	CO3	3	3	2	2	3	1	1	-	1	1	1	2
	CO4	3	2	1	3	2	1	1	1	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC02	Data Structure and Algorithms	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
CSC01 (Computer Programming)		CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]					
Course Outcomes	• CO1: Understanding the fundamental concepts of abstract data types, data structures, algorithms and time complexity analysis of algorithms. • CO2: Implementation of different abstract data types (array, linked list, stack, queue, tree, graph). • CO3: Implementation of different sorting and searching techniques along with their performance evaluation. • CO4: Analysis of the suitability/compatibility of different data structures based on the types of applications. • CO5: Design and development of algorithms for real-life applications.						
Topics Covered	**Introduction** (6L) Overview of Abstract Data Types (ADTs) and fundamental data structures. Concepts of static and dynamic memory allocation. Definition and structure of algorithms, with emphasis on time and space complexity analysis. Introduction to asymptotic notations: Big O, Big Ω						

	(Omega), and Big Θ (Theta). Discussion on how the choice of data structure affects algorithm performance. **Arrays** (2L) Arrays as an ADT. Representation of single and multi-dimensional arrays. Memory organization: row-major and column-major formats. Address computation for array elements. **Linked Lists** (6L) Linked lists as an ADT. Dynamic memory allocation and deallocation for linked list nodes. Comparison between arrays and linked lists. Types of linked lists: singly linked list, doubly linked list, and circular linked list. Fundamental operations: creation, traversal, insertion, and deletion at various positions. Additional operations: concatenation, searching, and sorting. Applications of linked lists in representing polynomials, sparse matrices, etc. Comparative analysis: Array vs. Linked List. **Stack** (5L) Stacks as an Abstract Data Type (ADT). Fundamental operations: push and pop. Implementation of stacks using arrays and linked lists. Applications of stacks: recursion handling, function call management, evaluation of postfix expressions, and infix to postfix expression conversion using stacks. **Queue** (4L) Queues as an ADT. Basic operations: enqueue and dequeue. Array-based implementation and its limitations. Circular queues. Linked list implementation of queues. Introduction to priority queues. **Binary Trees** (8L) Introduction to binary trees: definitions and fundamental properties. Memory representation of binary trees using arrays and linked lists. Tree traversal techniques: preorder, inorder, and postorder. Concepts of binary search trees and heaps. **Searching Algorithms** (2L) Linear search and binary search: algorithms and performance considerations. **Sorting Algorithms** (5L) Overview and implementation of sorting techniques: selection sort, insertion sort, quick sort, and merge sort. **Graph Algorithms** (4L) Graph representation using adjacency matrices and adjacency lists. Graph traversal algorithms: Breadth-First Search (BFS) and Depth-First Search (DFS).
Text Books, and/or reference material	**Text Books:** 1. R. F. Gilberg and B. A. Forouzan, "Data Structures: A pseudocode approach with C", 2nd Edition, CENGAGE Learning. 2. A. V. Aho, J. D. Ullman and J. E. Hopcroft, “Data Structures and Algorithms”, Addition Wesley. 3. Lipschutz, “Data Structures (Schaum’s Outline Series)”, Tata Mcgraw Hill. 4. E. Horowitz, S. Sahni, S. Anderson-Freed, “Fundamentals of Data Structures in C”, Universities Press; Second edition (2008). **Reference Books:** 1. Y. Langsam, M. J. Augenstein and A. N. Tanenbaum, "Data Structures using C and C++", Pearson, 2006. 2. Knuth, Donald E. The Art of Computer Programming. 3rd ed. Vols 1&2. Reading, MA: Addison-Wesley, 1997. ISBN: 0201896834. ISBN: 0201896842. ISBN: 0201896850. 3. Kleinberg and Eva Tardos. Algorithm Design. Addison-Wesley 2005 ISBN-13: 978-0321295354.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC02	CO1	3	-	1	1	1	-	-	-	-	-	-	-
	CO2	3	2	1	2	2	-	-	-	-	-	-	1
	CO3	3	2	1	2	2	-	-	-	-	-	-	1
	CO4	3	3	2	3	3	-	-	-	-	-	-	1
	CO5	3	3	3	3	3	-	-	-	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XEC02	Basic Electrical and Electronics Engineering	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
(10+2) level mathematics and physics		CT+MT+EA					

Course Outcomes	• CO1: Learn the fundamentals of electric circuits and analyze the circuits using laws and network theorems. • CO2: Gain the knowledge about magnetic circuits, electromagnetism and the basics of generation of alternating voltage. • CO3: Understand the behaviour of single phase and poly-phase AC circuits. CO4: Understand the fundamentals of semiconductor devices. • CO5: Analyze the design and characteristics of transistor-based electronic circuits. CO6: Evaluate operational amplifier-based circuits and logic gates.
Topics Covered	**1. Introduction to Electrical Systems and Basic Circuit Theory** (4L) Overview of electrical systems. Fundamentals of electric circuits: Ohm's law, Kirchhoff's current and voltage laws. Introduction to independent and dependent sources. Analysis of simple resistive circuits. **2. DC Network Theorems** (5L) Application of key network theorems: Superposition Theorem, Thevenin's Theorem, Norton's Theorem, and the Maximum Power Transfer Theorem for analyzing DC circuits. **3. Magnetic Circuits** (3L) Review of electromagnetic induction principles. Concepts of self and mutual inductance. Analysis and solution of magnetic circuits. **4. Alternating Current (AC) Fundamentals** (6L) Generation of alternating voltage and current, derivation of the EMF equation. Calculation of average and RMS values. Concepts of phase and phase difference. Phasor representation of AC quantities. Behavior of R-L-C circuits under AC excitation. Series and parallel resonance. **5. Polyphase Systems** (3L) Basics of three-phase systems and their advantages. Generation of three-phase voltages. Analysis of voltages, currents, and power in star and delta connections. Study of balanced and unbalanced three-phase circuits.

	6. Semiconductor Devices (6L) Structure, operation, and V-I characteristics of semiconductor diodes and Zener diodes. Applications of Zener diodes as voltage regulators. Introduction to Light Emitting Diodes (LEDs). **7. Transistors** (8L) Introduction to Bipolar Junction Transistor (BJT), Field Effect Transistor (FET), and Metal-Oxide Semiconductor FET (MOSFET). Basics of CMOS. V-I characteristics and working principles. Biasing techniques for BJTs: fixed bias, emitter bias, feedback bias, and voltage divider bias. Transistor as an amplifier. **8. Operational Amplifiers** (4L) Introduction to operational amplifiers and their applications. Implementation of inverting and non-inverting amplifiers, unity gain buffers, integrators, differentiators, and summing circuits. **9. Digital Logic and Memory Elements** (3L) Introduction to basic logic gates. Overview of memory elements including ROM and RAM.
Text Books, and/or reference material	**TEXT BOOKS** 1. Electrical & Electronic Technology by Hughes, Pearson Education India. 2. Introduction Electronic Devices & Circuit Theory, 11/e, 2012, Pearson: Boylestad & Nashelsky. 3. Electronics: Fundamentals and Applications By D. Chattopadhyay, P. C. Rakshit; New Age Int. Publication. **REFERENCE BOOKS** 1. Advanced Electrical Technology by H. Cotton, Reem Publication Pvt. Ltd. 2. Electrical Engineering fundamentals by Vincent Deltoro, Pearson Edu. India. 3. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill. 4. Electronics - Circuits and Systems, Fourth Edition by Owen Bishop. Electronics Fundamentals: Circuits, Devices & Applications (8e) by Thomas L. Floyd & David M. Buchla.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC02	CO1	3	3	3	3	3	1	1	1	1	1	1	1
	CO2	3	3	3	3	2	1	2	1	1	1	1	1
	CO3	3	3	3	3	3	2	2	1	1	1	1	1
	CO4	2	3	2	2	-	1	-	-	-	-	-	1
	CO5	3	2	1	2	2	1	-	-	2	-	-	1
	CO6	3	2	2	2	3	-	-	-	2	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS51	COMPUTER PROGRAMMING LABORATORY	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	• CO1: To understand the principle of operators, loops and branching statements. • CO2: Implementation of function, recursion, arrays, and pointers based several types of assignments. • CO3: To detail out the operations of strings. CO4: To understand structure and union. • CO5: Application of C-programming to solve various types of problems.
Topics Covered	**List of Experiments:** 1. **Expression Evaluation:** Implement programs to evaluate arithmetic and logical expressions. 2. **Conditional Statements and Branching:** Write programs using if, if-else, switch-case, and other branching constructs. 3. **Looping and Iterative Constructs:** Practice programs using for, while, and do-while loops for repetitive tasks. 4. **Array Applications:** Develop programs that demonstrate single-dimensional and multi-dimensional array operations. 5. **Functions and Pointers:** Create programs covering user-defined functions, call by value/reference, and basic pointer operations. 6. **String Manipulation:** Implement string operations using both arrays and pointers. 7. **Recursion:** Write recursive programs for mathematical problems (e.g., factorial, Fibonacci, tower of Hanoi). 8. **Structures and Unions:** Develop programs using structures and unions for data organization and manipulation. 9. **File Handling:** Implement basic file operations such as file creation, reading, writing, and appending. 10. **Case Studies:** Solve real-life or problem-oriented case studies using a combination of the above concepts.
Text Books, and/or reference material	**Text Books:** 1. Y. Kanetkar, "Let Us C", BPB Publications, Sixteenth edition, 2017. 2. B. S. Gottfried, "Programming with C", McGraw Hill Education, 4th Ed., 2018. 3. E. Balagurusamy, "Computing Fundamentals and C Programming", McGraw Hill Education; Second edition, 2017. **Reference Books:** 1. P. Dey and M. Ghosh, "Computer fundamentals and programming in C", Oxford press, 2013. 2. R. Thareja, "Computer fundamentals and programming in C", Oxford press, 2013. 3. Schaum's Outline, Programming with C.

Mapping of CO (Course outcome) and PO (Programme Outcome

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS51	CO1	3	3	2	-	-	2	-	-	-	-	-	-
	CO2	2	2	1	-	-	1	-	-	-	-	-	-
	CO3	3	2	2	-	-	1	-	-	-	-	-	-
	CO4	2	3	2	-	-	2	1	-	-	-	-	-
	CO5	3	3	3	-	1	2	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHS51	Physics Laboratory	PCR	0	0	2	2	1

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+EA

Course Outcomes	• CO1: To realize and apply different techniques for measuring refractive indices of different materials. • CO2: To realize different types of waveforms in electrical signals using CRO. CO3: To understand charging and discharging mechanism of a capacitor. • CO4: To understand interference, diffraction and polarization related optical phenomena. • CO5: To acquire basic knowledge of light propagation through fibers.
Topics Covered	1. Measurement of the refractive index of a liquid using a travelling microscope. 2. Determination of the refractive index of a prism material using a spectrometer. 3. Measurement of amplitude and frequency of electrical signals using an oscilloscope. 4. Analysis of RC circuit characteristics. 5. Verification of Brewster's law or Malus' law using laser light. 6. Observation of light diffraction using a grating. 7. Study of light interference using Newton's rings apparatus. 8. Measurement of the numerical aperture of an optical fiber. 9. Experimental determination of Planck's constant.
Text Books, and/or reference material	**SUGGESTED BOOKS**: 1. A Text Book on Practical Physics – K. G. Mazumdar and B. Ghosh 2. Practical Physics – Worsnop and Flint

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS51	CHEMISTRY LABORATORY	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	• CO1: To learn basic analytical techniques useful for engineering applications. • CO2: Synthesis and characterization methods of few organic, inorganic and polymer compounds of industrial importance. • CO3: Learn chromatographic separation methods. • CO4: Applications of spectroscopic measurements.
Topics Covered	• Experiments based on pH metry: Determination of dissociation constant of weak acids by pH meter. • Experiments based on conductivity measurement: Determination of amount of HCl by conductometric titration with NaOH. • Estimation of metal ion: Estimation of Fe2+ by permangnomentry • Estimation of metal ion: Determ. of total hardness of water by EDTA titration. • Synthesis and characterization of inorganic complexes: e. g. Mn(acac)3, Fe(acac)3, cis-bis(glycinato)copper (II) monohydrate and their characterization by m. p. , FTIR etc. • Synthesis and charact. of organic compounds: e.g.Dibenzylideneacetone. • Synthesis of polymer: polymethylmethacrylate • Verification of Beer-Lamberts law and determination of amount of iron present in a supplied solution. • Chromatography: Separation of two amino acids by paper chromatography • Determination of saponification value of fat/ vegetable oil
Text Books, and/or reference material	Suggested Text Books: 1. Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall 2. Advanced Physical Chemistry Experiments: By Gurtu&Gurtu 3. Comprehensive Practical Organic Chemistry: Qualitative Analysis By V. K. Ahluwalia and S. Dhingra Suggested Reference Books: 1. Practical Chemistry By R.C. Bhattacharya 2. Selected experiments in Physical Chemistry By N. G. Mukherjee

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES51	ENGINEERING GRAPHICS	PCR	1	0	3	4	2.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	CO1: Ability of mental visualization of different objects CO2: Theoretical knowledge of orthographic projection to solve problems on one/two/three dimensional objects CO3: Able to read/interpret industrial drawing and to communicate with relevant people
Topics Covered	Graphics as language of communication; technical drawing tools and their up-keep; types of lines; construction of geometrical figures; lettering and dimensioning. [6] Construction and use of scales; construction of curves of engineering importance such as curves of conic section; spirals, cycloids, involutes and different loci of points; use of equations for drawing some curves. [9] Descriptive geometry: necessity and importance of orthographic projection; horizontal and vertical reference planes; coordinate of points; orthographic projection of points and lines situated in different quadrants, viz. 1st, 2nd, 3rd and 4th quadrants; traces of lines. First angle and third angle projection of lines and planes; views from top, front and left (or right); true length and true inclination of lines with planes of projections; primary auxiliary projection of points, lines and planes; auxiliary plan and auxiliary elevation. [9] Projection of simple regular solids, viz. prisms, cubes, cylinders, pyramids, cones, tetrahedrons, spheres, hemi-spheres etc. [6] Section of solids; section by perpendicular planes; sectional views; true shapes of sections. [6] Dimensional techniques; international and national standards (ISO and BIS). [3] Freehand graphics. [3]
Text Books, and/or reference material	Suggested Text Books: 1) Engineering Drawing and Graphics – K Venugopal 2) Engineering Drawing – N D Bhat 3) Practical Geometry and Engineering Graphics – W Abbott

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES52	Basic Electrical and Electronics Laboratory	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	CO1: Learn to analyse the electric circuits using network theorems. CO2: Understand the characteristics of fluorescent lamp and compact fluorescent lamp. CO3: Analyze the behaviour of single phase and three phase AC circuits. CO4: Understand the application of electronics components, diode circuits as rectifier circuits and voltage regulators. CO5: Evaluate and study the performance of the transistor as a switch. CO6: Create inverting and non-inverting amplifier circuits using Op-Amp.
Labs Conducted	1. Verification of the network theorems (DC). 2. Study of the characteristics of fluorescent and compact fluorescent lamp. 3. Analysis of the three phase system for star and delta connected load. 4. Study of the series and parallel R-L-C circuit. 5. Identify and understand the use of different electronic and electrical instruments, various electronic components. 6. Study of half-wave and full-wave (bridge) rectifier with and without capacitor filter circuit. Zener diode as a voltage regulator. 7. Study the performance of a transistor as a switch through NOT gate 8. Realization of Inverting and Non-inverting amplifier using Op-Amp.
Text Books, and/or reference material	**TEXT BOOK** 1. Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru , J M Chuma, H U Ezea. 2. Experiments Manual for use with Electronic Principles (Engineering Technologies and the Trades) by Albert Paul Malvino Dr., David J. Bates, et al. **REFERENCE BOOKS** 1. Laboratory Courses in Electrical Engineering (5^{th} Edition) by S. G. Tarnekar, P. K. Kharbanda, S. B. Bodhke, S. D. Naik, D. J. Dahigaonkar (S. Chand Publications). 2. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill. 3. Electronic Principles, by Albert Paul Malvino Dr. and David J. Bate.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES52	CO1	3	3	3	3	3	1	1	1	2	2	2	3
	CO2	3	3	2	3	3	3	1	1	2	2	2	3
	CO3	3	3	2	3	3	2	1	1	2	2	2	3
	CO4	3	3	3	3	3	1	1	1	2	2	2	3
	CO5	3	2	1	2	2	1	-	-	2	-	-	-
	CO6	3	2	2	2	3	-	-	-	2	-	-	-
	CO7	3	3	2	2	-	-	-	-	2	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS52	DATA STRUCTURES AND ALGORITHMS LABORATORY	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	CO1: Understanding the suitability and compatibility of array and linked list implementations for different application problems. CO2: Understanding the concept of abstract data types from real-life scenarios and their implementation in computing system. CO3: Identify, design and implementation of stack, queue, binary tree, and graph as applicable for given problem. CO4: Implementation of different searching and sorting techniques using appropriate data structures and perform efficiency analysis. CO5: Create efficient algorithms for real-life applications.
Labs Conducted	**List of Experiments:** 1. Application of arrays using dynamic memory allocation. 2. Implementation and Applications of linked lists. 3. Implementation of stack, and applications of stack. 4. Implementation of queue, applications of queue: Priority queue 5. Implementation of Binary tree, Binary tree traversal: Preorder, Inorder and Postorder traversal. 6. Implementation of binary search tree and operations on it. 7. Implementation of linear search, binary search (recursive, non-recursive). 8. Implementation of different sorting algorithms. 9. Implementation of graph algorithms: Breadth first search, Depth first search. 10. Case Studies.
Text Books, and/or reference material	**Text Books:** 1. S. Lipschutz, "Data Structures (Schaum's Outline Series)", McGraw Hill Education; First edition (2017). 2. E. Horowitz, S. Sahni, S. Anderson-Freed, "Fundamentals of Data Structures in C", Universities Press; Second edition (2008). 3. E. Balagurusamy, "Programming in ANSI C", McGraw Hill Education India Private Limited, Seventh edition (2017). **Reference Books:** 4. 1. B. S. Gottfried, "Programming with C", McGraw Hill Education, 4th Ed. (2018).

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS52	CO1	-	1	1	1	-	-	-	-	-	-	-	-
	CO2	-	1	1	3	-	-	-	-	-	-	-	-
	CO3	2	2	3	2	1	-	-	-	-	-	-	-
	CO4	2	2	2	1	1	-	-	-	-	-	-	-
	CO5	3	3	3	3	3	-	1	1	-	-	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XSS51	Extra Academic Activities	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	CO1: Social Interaction through the medium of sports CO2: Team building and self defence
Labs Conducted	**YOGA** 5. Introduction of Yoga- Suryanamaskar. 1L 6. Sitting Posture / Asanas – Padmasana, Vajrasana, Ardha Kurmasana, Ustrasana, Janusirshasana, Gomukhasana, Bhadrasana. 7L 7. Mudra- Gyana Mudra, Chin Mudra. 1L 8. Laying Posture/ Asana-Pavana Mukhtasana, Uttana Padasana, Sarpasana, Bhujangasana (Cobra Pose), Eka Pada Salabhasana, Dhanurasana, Chakrasana, Viparitkarani, Ardha Halasana (Half Plough Pose), Naukasana (Boat Posture), Shavasana (Relaxing Pose) , Makarasana. 7L 9. Meditation-Om Chant. 1L 10. Standing Posture / Asana-Tadasana (Mountain Pose), Vrikshana (Tree Pose), Ardha Chandrasana, Padahastasana, Ardha Chakrasana (Half Wheel Posture). 5L 11. Pranayama-Deep Breathing, Anulom Vilom, Shitali, Bhramari. 5L 12. Kriya- Kapalbhati 1L **TAEKWONDO** 13. Introduction About Taekwondo- Meaning Of Taekwondo, Korean Language Of Dress, Fighting Area, Punch, Block, Kicks Etc. 1L 14. Stance- Ready Stance, Walking Stance, Front Stance, Back Stance. 2L 15. Punch Technique- Front Fist Punch, Double Fist Punch, With Stance Etc. Blocks- Upper Blocks, Middle Block, Side Block, Suto Etc. 4L 16. Foot Technique- Standing Kick, Front Kick, Doliyo, Back Kick Etc. 6L 17. Poomsae (Forms)- Jang, Yi Jang.6L 18. Self Defense Technique- Self Defense from Arms, Fist and Punch. 4L 19. Sparring (Kyorugi)- One Step Sparring 2L 20. Combination Technique- Combined Kick And Punch. 2L 21. Project Work 1L

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS51	CO1	-	-	-	-	-	2	-	-	2	-	-	1
	CO2	-	-	-	-	-	-	-	2	3	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

THIRD SEMESTER

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC331	MATHEMATICS-III	PCR	3	1	0	4	4
Pre-requisites		Basic knowledge of topics included in MAC01 & MAC02					

Course Outcomes	CO1: Acquire the idea about mathematical formulations of phenomena in physics and engineering. CO2: To understand the common numerical methods to obtain the approximate solutions for the intractable mathematical problems. CO3: To understand the basics of complex analysis and its role in modern mathematics and applied contexts. CO4: To understand the optimization methods and algorithms developed for solving various types of optimization problems.
Topics Covered	**Partial Differential Equations (PDE):** Formation of PDEs; Lagrange method for solution of first order quasilinear PDE; Charpit method for first order nonlinear PDE; Homogenous and Nonhomogeneous linear PDE with constant coefficients: Complimentary Function, Particular integral; Classification of second order linear PDE and canonical forms; Initial & Boundary Value Problems involving one dimensional wave equation, one dimensional heat equation and two dimensional Laplace equation. [14] **Numerical Methods:** Significant digits, Errors; Difference operators; Newton's Forward, Backward and Lagrange's interpolation formulae; Numerical solutions of nonlinear algebraic/transcendental equations by Bisection and Newton-Raphson methods; Trapezoidal and Simpson's 1/3 rule for numerical integration; Euler's method and modified Eular's methods for solving first order differential equations. [14] **Complex Analysis:** Functions of complex variable, Limit, Continuity and Derivative; Analytic function; Harmonic function; Conformal transformation and Bilinear transformation; Complex integration; Cauchy's integral theorem; Cauchy's integral formula; Taylor's theorem, Laurent's theorem (Statement only); Singular points and residues; Cauchy's residue theorem. [17] **Optimization:** **Mathematical Preliminaries:** Hyperplanes and Linear Varieties; Convex Sets, Polytopes and Polyhedra. [2] **Linear Programming Problem (LPP):** Introduction; Formulation of linear programming problem (LPP); Graphical method for its solution; Standard form of LPP; Basic feasible solutions; Simplex Method for solving LPP. [9]
Text Books, and/or reference material	**Text Books:** 1. An Elementary Course in Partial Differential Equations-T. Amarnath 2. Numerical Methods for scientific & Engineering Computation- M.K.Jain, S.R.K. Iyengar & R.K. Jain. 3. Foundations of Complex Analysis- S. Ponnuswami 4. Operations Research Principles and Practices- Ravindran, Phillips, Solberg 5. Advanced Engineering Mathematics- E. Kreyszig **Reference Books:** 1. Complex Analysis-L. V. Ahfors 2. Elements of partial differential equations- I. N. Sneddon 3. Operations Research- H. A. Taha

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 56</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECC301</td><td>Network Analysis and Synthesis</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods:
Continuous (CT), Mid-Term (MT), End Assessment (EA)</td></tr>
<tr><td colspan="3">Engineering Physics (PHC01),
Mathematics I and II (MAC01, MAC02)</td><td colspan="5">The assessment methods comprise of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On successful completion of this course, students should have the skills and knowledge to:
CO1. Applications of network theorems and Laplace transform in A.C. and D.C circuit analysis, time domain analysis of simple RLC circuits, transient analysis.
CO2. Graph Theory. Characterization of two port networks and Z, Y, ABCD and h parameters, inter-relationships between the parameters.
CO3. Representation of two port network in terms of T , Π and lattice networks, Bisection theorem and its applications, image impedance, characteristic impedance and propagation function
CO4. Design of various types of attenuators and determination of insertion loss
CO5.Design of prototype low pass, high pass, bandpass and bandstop filters, constant K-type filters, modern filter design concepts, application of filters.
CO6.Synthesis of LC, RC and RL driving point admittance functions using Foster and Cauer first and second forms.</td></tr>
<tr><td>Topics Covered/ Syllabus</td><td colspan="7">Unit I:Network Functions and Transient analysis
(L=08 hrs.+ T=3 hrs.)
Transform Impedances,Network Theorems, Network functions of one port and two port networks, concept of poles and zeros, properties of driving point and transfer functions, time response and stability from pole zero plot, Laplace transform of various functions, Applications of Laplace transform in A.C. and D.C circuit analysis, Time domain analysis of simple RLC circuits, transient analysis.
Unit II: Two Port Networks
(L=09 hrs.+T=3hrs.)
Characterization of two port networks, Z, Y, ABCD and h parameters, Reciprocity and symmetry. Inter-relationships between the parameters, Inter-connections of two port networks, T & Π Representation, Bisection theorem, Lattice network, Image impedance, Characteristic impedance and propagation function
Unit III: Network Topology
(L=04 hrs +T=2 hrs.)
Network graph, Tree, Incidence matrix - Fundamental cutsets and fundamental loops – Tie set and cut set schedules – V shift and I shift – Formulation of equilibrium equation on loop basis and node basis, Formulation of equilibrium equation in matrix form – Duality, Construction of dual of a network.
Unit IV: Filters
(L=07 hrs.+ T=3 hrs.)
Filters: conditions of passband and stopband, design of prototype low pass, high pass, bandpass and bandstop sections, constant K-type filters, modern filter design concepts, application of filters.
Unit V: Introduction to Network Synthesis
(L=07 hrs.+ T=3 hrs.)
Hurwitz polynomials and properties – Positive real functions and its properties; definition properties; properties of LC, RC and RL driving point functions, synthesis of LC, RC and RL driving point admittance functions using Foster and Cauer first and second forms.</td></tr>
</table>

Text Books, and/or Reference material	**Text Books**: 1. E. Van Valkenburg, "Network Analysis", Prentice Hall of India 2. C. L Wadhwa, "Network Analysis and Synthesis" New Age International Publishers, 2007, 3. D. Roy Choudhury, "Networks and Systems" Wiley Eastern Ltd. 4. John D. Ryder, "Networks, Lines & Fields", 2nd edition, Pearson
	Reference Books/materials: 1. B. C. Kuo, "Network Analysis and Synthesis", John Wiley 2. E. Van Valkenburg, "An Introduction to Modern Network Synthesis", Wiley Eastern Ltd. 3. A. Chakrabarti, "Circuit Theory" Dhanpat Rai& Co.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)														
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	2	2	1	-	-	-	-	-	-	3	2	3	2
CO#2	3	3	2	3	2	-	-	-	-	-	-	3	3	2	2
CO#3	3	3	3	3	2	-	-	-	-	-	-	3	3	3	2
CO#4	3	2	2	3	2	-	-	-	-	-	-	2	3	3	2
CO#5	3	3	3	3	2	1	-	-	-	-	-	2	3	2	2
CO #6	3	2	3	3	2	-	-	-	-	-	-	2	2	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total number of contact hours / week				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC302	Semiconductor Devices and Technology	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
XEC02: Basic Electrical and Electronics Engineering		CT+EA					
Course Outcomes		● **CO1: Explain** basic semiconductor material physics ● **CO2: Analyze** the characteristics of various electronic devices like diode, transistor etc. ● **CO3: Illustrate** the qualitative knowledge of special purpose devices. ● **CO4: Understand** basics of fabrication processes ● **CO5: Learn** Device Scaling and the latest technological changes					
Topics Covered		**Module 1: Physics of Semiconductor Devices [7 hrs]** Equilibrium carrier concentrations; Thermal Equilibrium and wave particle duality; Intrinsic semiconductor : Bond and band models; Extrinsic semiconductor: Bond and band models, density of states and Fermi Dirac statistics, calculation of carrier concentrations					

	from allowed energy states, ,Carrier transport; Random motion; Drift Diffusion Generation/Recombination; mobility, velocity saturation, Excess carriers; Injection level; Lifetime; Direct and indirect semiconductors; Procedure for analyzing semiconductor devices; Basic equations and approximations **Module 2: P-N Junction Diode [7 hrs]** Unbiased & biased p-n junction, Diode current equation, Voltage-current characteristics, Junction capacitances, Effect of high field on charge carriers in semiconductors, Impact ionization, Carrier multiplication, avalanche breakdown of junction, Zener diode and Zener breakdown, Photodiode, Solar cell, Metal-Semiconductor Schottky Barrier Diode. **Module 3: Field Effect Transistor [8 hrs]** Device structure and operation, Metal Oxide Semiconductor (MOS) capacitance: C-V characteristics, MOS Device Physics; threshold voltage, body effect. MOSFET: Device structure and operation, MOSFET Device Physics, Common Source DC characteristics. FET small-signal equivalent circuit. **Module 4: Bipolar Junction Transistor (BJT) [7 hrs]:** Basic principle of operation, Base width modulation, Eber-Moll model, hybrid-pi model, Equivalent circuit of BJT, Switching Characteristics, Photo transistor, High frequency transistor. **Module 5: Process Technology [7 hrs]** Crystal Growth, Oxidation, Diffusion, Implantation, Lithography, Thin Film Deposition, Metallization, CMOS process flow **Module 6: Recent Developments [5 hrs]** Moore's Law and scaling challenges, Emerging Devices, FinFET, CFET
Text Books, and/or reference material	Text Books: 1. Solid State Electronics Devices- Streetman, Banerjee, PHI, New Delhi 2. Semiconductor Physics and Devices – D.A. Neaman, McGraw Hill 3. Physics of Semiconductor devices, S. M. Sze, John Willey & Sons, N.Y 4. Introduction to Semiconductor Materials and Devices, M.S. Tyagi, John Wiley, 2004 References 1. Advanced Semiconductor Fundamentals, Robert Pierret, Pearson, 2002 2. Fundamentals of Solid State Electronics, C.T. Sah, World Scientific Publishing, 1991 3. Semiconductor Devices: Modelling and Technology, Amitava DasGupta and Nandita DasGupta, PHI, 2004

Course Articulation Matrix (ECC302)

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

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 52</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECC303</td><td>Signals and Systems</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Prerequisites</td><td colspan="5">Course Assessment methods
(Continuous (CT), Mid-Term (MT), End Assessment (EA))</td></tr>
<tr><td colspan="3">Mathematics I and II (MAC01, MAC02)</td><td colspan="5">The assessment methods comprise of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.</td></tr>
<tr><td colspan="3">Course Outcomes</td><td colspan="5">● CO1: To realize the difference between (i) continuous and discrete signals, (ii) analog and digital signals.
● CO2: Understand mathematical techniques to solve problems involving convolution, filtering, modulation and sampling.
● CO3: Ability to apply mathematical transforms for signals and systems analysis.
● CO4: Analysis of stable LTI systems.
● CO5: Practical realization of various forms of anti-aliasing filters.</td></tr>
<tr><td colspan="3">Topics Covered/ Syllabus</td><td colspan="5">M1. Classification of signals, basic operations on signals such as time shifting and time scaling, elementary signals, impulse function, system properties including stability, memory, causality, invertibility, time invariance, linearity (L=04 hrs.+ T=2 hrs.)
M2. Convolution sum, convolution integral, correlation of signals, relation between convolution and correlation, interconnection of LTI systems, relation between system properties and impulse response, step response (L=06 hrs.+ T=2 hrs.)
M3. Discrete-time difference equation models, continuous-time differential equation models, natural response, forced response, transient response, system stability (L=04 hrs.+ T=2 hrs.)
M4. Fourier series, Discrete-Time Fourier Series (DTFS), Fourier Transform (FT), Discrete-Time Fourier Transform (DTFT), properties of Fourier representations, application to real-time systems (L=06 hrs.+ T=2 hrs.)
M5. Relationships among Fourier series, FT, DTFS, and DTFT, applications to mixed signal classes, sampling of signals, analysis of sampling using Fourier transforms (L=04 hrs.+ T=2 hrs.)
M6. Discrete Fourier Transform (DFT), properties of DFT, circular convolution, DFT computation, decimation-in-time FFT algorithm, decimation-in-frequency FFT algorithm(L=04 hrs.+ T=1 hrs.)
M7. Complex frequency concept, bilateral Laplace transform, unilateral Laplace transform, Laplace transform properties, inverse Laplace transform, solving differential equations with initial conditions, transfer function, causality analysis, stability analysis, frequency response from poles and zeros(L=05 hrs.+ T=2 hrs.)
M8. Z-transform, Z-transform properties, inverse Z-transform, transfer function, causality, stability, frequency response from poles and zeros, computational structures for discrete-time LTI systems(L=04 hrs.+ T=2 hrs.)</td></tr>
<tr><td colspan="3">Text Books, and / or reference material</td><td colspan="5">Text Books:
1. Signals and Systems -- Simon Haykin.
2. Principles of Linear Signals and Systems -- B.P.Lathi
3. Signals and Systems -- Tarun Kumar Rawat

Reference Books:</td></tr>
</table>

	1. Signals and Systems: Schaum's Outline. 2. Discrete-Time Signal Processing -- Oppenheim, Schafer and Buck. 3. Digital Signal Processing -- Proakis and Manolakis. 4. a Wavelet tour of signal processing, The Sparse Way -- Stéphane Mallat.

COURSE ARTICULATION MATRIX

PO / CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	**3**	**2**	**3**	**2**	**2**	**3**	**1**	**1**	**1**	**1**	**1**	**1**	**3**	**2**	**2**
CO#2	**2**	**2**	**2**	**3**	**2**	**3**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**3**	**3**
CO#3	**3**	**2**	**2**	**2**	**3**	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**2**	**3**	**2**
CO#4	**2**	**3**	**3**	**3**	**3**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**3**	**2**	**2**
CO#5	**2**	**2**	**2**	**3**	**2**	**3**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**3**	**3**

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 56				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC304	Digital Circuits and Systems	PCR (CORE)	3	1	0	4	4

Pre-requisites : ▼ Basic Electrical and Electronics Engineering (XEC02),	**Course Assessment Methods :** (Continuous Assessment (CA: 15 %), Mid-Term (MT:25 %), End-Term Assessment (ET: 60%))
	The assessment methods comprise of Quizzes, multiple choice type questions, Assignments, involving real world examples, and subjective/numerical questions (online/offline) or assessed through pen and paper.
Course Outcomes	• **CO1**: Understand rules of Boolean algebra and use it for logic synthesis. • **CO2**: Design logic circuits using switches, transistors and integrated circuit building blocks. • **CO3**: Understand binary number system, and design corresponding arithmetic circuits. • **CO4**: State and use Shannon's decomposition using 2:1 Muxes, N:1 Muxes. • **CO5**: Learn sequential circuit building blocks and implement Finite State Machines. • **CO6**: Design counters using D/JK/T Flip-flops.
Outline/ Topics Covered	**Module 1: Definition of Digital System(L- 1, T-1)** Introduction: Definition of Analog & Digital information. Characteristics of Digital Circuits. Advantages of Digital systems. **Module 2: Boolean Algebra (L-1 , T- 1)** Introduction – rules of Boolean Algebra, axioms, De´Morgan's theorems **Module 3: Logic Gates in CMOS (L-2 , T- 1)** Logic Gates: Basic Gates, Universal Gates, Realization of logic gates using switches, Transistors (CMOS and BJT) as switch. **Module 4: Combinational Circuits I (L-4 , T-2)**

	Logic Synthesis: Two-level synthesis, Canonical forms, SOP/POS forms, SOP; Minimization of logical function by - i) Algebraic method, ii) Karnaugh Map method and iii) Quine Mccluskey Method. **Module 5: Combinational Circuits II**: **(L-4 , T-2)** Multiplexer, DeMultiplexer, Decoder, Encoder, Comparator, parity checker, driver tri-state logic, Shannon's Decomposition; design of combinational circuits using these blocks and their applications. **Module 6:** Digital Arithmetic: **(L-3 , T- 2)** Digital Arithmetic: Number systems, Binary arithmetic, Representing negative numbers – sign-magnitude, 1's complement and 2's complement representations; Floating point IEEE format. Arithmetic circuits - Half Adder and Full adder Circuits, multi-bit ripple-carry adder and subtractor circuits. Realization of these circuits using Multiplexers. **Module 7:** Sequential Circuits: **(L- 6, T-4)** Definition, Elements of sequential circuits - Latches and Registers, Different kinds of flip-flops – R-S, J-K, Master-slave arrangement, D, and T type registers; Finite state machines - Moore and Mealy machines; Typical sequential circuits, -counters, shift registers and sequence generator; synchronous and asynchronous circuits.
Text Books, and/ Reference materials	**Text Books**: 1. M. Morris Mano, Digital Design, 3rd Edition, Prentice Hall of India, 2003 or Pearson Education (Singapore) 2003. 2. Milos Ercegovac, Tomas Lang, Introduction To Digital Systems, John Wiley 2011. **Reference Books**: 1. David Harris, Sarah L. Harris, Digital Design and Computer Architecture, RISC-V Edition,, Morgan Kaufmann Publishers 2021. 2. Zvi Kohavi and Niraj K Jha, Switching and Finite Automata Theory, 3rd Edition, Cambridge, 2010. 3. Thomas L. Floyd, Digital Fundamentals, 8th Edition, Pearson Education Inc, New Delhi, 2005. 4. Donald D. Givone, Digital Principles and Design, TMH, 2016. 5. 5. John F.Wakerly, Digital Design, Fourth Edition, Pearson/PHI, 2006.

COURSE ARTICULATION MATRIX(ECC304)

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	2	2	1	-	-	-	-	-	-	3	3	2	2
CO#2	2	3	3	3	2	-	-	-	-	-	-	2	3	2	1
CO#3	2	3	3	3	3	-	-	-	-	-	-	3	2	3	3
CO#4	2	3	3	3	3	-	-	-	-	-	-	2	3	2	2
CO#5	3	3	3	2	3	-	-	-	-	-	-	3	2	3	2
CO#6	1	2	3	1	1	-	-	-	-	-	-	2	1	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 27				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS351	Network Analysis and Synthesis Lab	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods: Continuous (CT) and End Assessment (EA)					
Basic Electrical and Electronics Engineering (XEC02)		CT+EA					

Course Outcomes	CO#1 Understand the basics of DC (direct current) circuits. CO#2 Use Mutisim Simulator for circuit simulation CO#3 Able to apply network circuit theorems to analyze electrical circuits CO#4 Use an oscilloscope to measure frequency, period, voltage (magnitude, peak-to-peak, maximum, minimum, and etc), DC offset, etc, of the waveform CO#5 Understand the difference between over-damped, critically damped and under-damped circuits from the observation of step response.
Laboratory experiments covered	1. Experiment with DC Measurements 2. Experiment with AC Measurements 3. Experiment with Network Analysis Methods 4. Experiment with First Order Circuits 5. Experiment with Second Order Circuits 6. Experiment with Sinusoidal Steady State 7. Experiment with Series & Parallel Resonance 8. Experiment with Transfer Functions 9. Experiment with Frequency Response Approach: Laboratory experiments of this course are devoted to elementary design of linear circuits. In particular, time is devoted to (a) the transient voltage response of RC, RL and RLC circuits, (b) the sinusoidal steady-state response of RC, RL and RLC circuits, and (c) the frequency response of series RLC resonance networks, and the impacts on the frequency response by varying capacitance and resistance.
Text Books, and/or reference material	Reference Books/ Materials: 1. B. C. Kuo, "Network Analysis and Synthesis", John Wiley 2. E. Van Valkenburg, "An Introduction to Modern Network Synthesis", Wiley Eastern Ltd. 3. Teri L. Piatt (Author), Kyle E. Laferty, "Circuit Analysis Laboratory Workbook (Synthesis Lectures on Electrical Engineering) Lab Manual, Workbook Edition" Morgan & Claypool. 4. Laboratory Instruction Manual.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	1	2	1	1	-	-	-	1	1	-	1	2	1	1
CO#2	3	2	2	1	1	1	-	1	1	1	-	1	2	1	1
CO#3	3	3	3	1	1	-	-	-	1	1	-	1	3	3	2
CO#4	1	2	1	1	1	-	-	-	1	1	-	1	3	3	2
CO#5	2	3	1	2	1	-	-	-	1	1	-	1	2	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 30</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECS352</td><td>Semiconductor Devices Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>2</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods:
Continuous (CT), End Assessment (EA)</td></tr>
<tr><td colspan="3">Basic Electrical and Electronics Engineering (XEC02), Basic Electrical and Electronics Engineering Laboratory (XES52)</td><td colspan="5">The assessment methods comprises of quizzes and multiple choice type questions based on laboratory work and developing experimental set ups.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Identify various semiconductor devices.
CO2: Interpret the characteristics of semiconductor devices</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Experiment :1
To Study and verify the functionality of PN junction diode in forward and reverse bias
Experiment: 2
To study the characteristic curve of a Zener diode.
Experiment: 3
To measure I-V characteristics of light emitting diodes (LEDs).
Experiment: 4
To study the DC characteristics of a Bipolar Junction Transistor (BJT) in common base (CB) mode.
Experiment: 5
To study the DC characteristics of a Bipolar Junction Transistor (BJT) in common emitter (CE) mode
Experiment: 6
To study the transfer characteristics of MOSFET and find out the threshold voltage.
Experiment: 7
To study the Drain characteristics of MOSFET.
Experiment: 8
To simulate C-V characteristics of the MOS capacitor
Experiment: 9
To study the transfer and drain characteristics of a JFET
Experiment: 10
To study the characteristics of UJT.
Experiment: 11
To study the characteristics of SCR.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Book:
1. Fundamentals of Electronic Devices and Circuits Laboratory Manual ,David A. Bell Oxford University Press
2. Electronic Devices, Thomas L Floyd,</td></tr>
</table>

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1															

CO#2															
CO#3															
CO#4															

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 30				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS353	Digital Circuits and Systems Laboratory	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods: Continuous (CT), End Assessment (EA)					
Basic Electrical and Electronics Engineering (XEC02)		The assessment methods comprises of quizzes and multiple choice type questions based on laboratory work and developing experimental set ups with verification of theory (ECC405).					

Course Outcomes	After conducting the laboratory experiments student will be able to: **CO1**: Understand digital circuits as basic building blocks of electrical communication, control systems with enhanced problem solving skills. **CO2**: Enrich knowledge of historical developments with facts that led to this theory leading to Integrated Circuits domain. **CO3**: Design and develop complex digital circuits for electronics appliances. **CO4**: Develop subsystems for the design of digital computers.
Topics Covered	**Experiment :1** **1.1** Design of half adder and half subtractor circuit using NAND/NOR gates only. **1.2** Design of 5-bit even / odd parity checker circuit using XOR gate. **Experiment: 2** **2.1** Realization of multiplexer as universal logic gate. **2.2** Design full adder and full subtractor circuit using4:1 multiplexer **Experiment: 3** **3.1** Realising a BCD to Decimal decoder circuit using decoder driver and seven segment LED display. **3.2** Verifying the function table of 8 to 3 line priority encoder. **Experiment: 4** **4.1** Design of four bit one's complement binary adder / subtractor circuit. **4.2** Design of four bit two's complement binary adder / subtractor circuit. **4.3** Design of four and five bit digital magnitude comparator. **Experiment: 5** **5.1** Verification of excitation table of J-K flip-flop. **5.2** Verification of excitation table of D flip-flop. **5.3** Design of T type flip flop from D type flip-flop. **Experiment: 6** **6.1** Design of Asynchronous up counter using J-K flip-flop. **6.2** Design of Synchronous up counter using D flip-flop. **Experiment: 7** **7.1** Study of asynchronous decade counter IC, 7490 in different modes. **7.2** Study of asynchronous binary counter or mod 16 counter IC 7493 in different modes. **Experiment: 8** **8.1** Study of synchronous decade counter IC 74160 in different modes.

	8.2 Study of synchronous up / down counter IC 74192. **Experiment: 9** **9.1** Study of 64-bit read / write memory. **9.2** Study of 4-bit universal shift register. **Experiment: 10** **10.1** Study of 4-bit Arithmetic Logic Unit (ALU).
Text Books, and/or reference material	**Text Book**: 1. M. Morris Mano, Digital Design, 3rd Edition, Prentice Hall of India Pvt. Ltd., 2003 / Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2003. **Reference Books**: 1. John.M Yarbrough, Digital Logic Applications and Design, Thomson Learning, 2002. 2. Charles H.Roth. Fundamentals of Logic Design, Thomson Learning, 2004. 3. William H. Gothmann, Digital Electronics, 2nd Edition, PHI, 1982. 4. Thomas L. Floyd, Digital Fundamentals, 8th Edition, Pearson Education Inc, 2005 5. Donald D. Givone, Digital Principles and Design, McGraw Hill, 2016. 6. John F.Wakerly, Digital Design, Fourth Edition, Pearson/PHI, 2006.

COURSE ARTICULATION MATRIX (ECS353)

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	1	1	-	-	-	-	-	1	1	1	2	2	2
CO#2	3	3	2	2	1	-	-	-	-	1	-	-	2	3	2
CO#3	3	3	2	2	1	-	-	-	-	1	-	-	2	2	2
CO#4	3	2	-	1	-	-	-	-	-	-	-	-	2	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

FOURTH SEMESTER

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC401	Communication Systems I	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
ECC303 (Signals and Systems)		CT+EA					

Course Outcomes	• **CO1: Explain** amplitude modulation in the time and frequency domains and understand corresponding circuits, signals and spectra. • **CO2: Explain** angle modulation in the time and frequency domains and understand corresponding circuits, signals and spectra. • **CO3: Learn** various pulse communication systems. • **CO4: Understand** basics of analog-to-digital conversion.
Topics Covered	**Module 1: Introduction [3 hrs.]** Advantages of Electrical communication; block diagram of an electrical communication system, the fundamental limitation of communication systems. Communication channels and propagation characteristics. **Module 2: Amplitude Modulation and Demodulation [10 hrs.]** DSB, SSB, spectra, circuits and systems, superheterodyne receiver. **Module 3: Angle Modulation and Demodulation [5 hrs]** Theory, spectra, circuits and systems. **Module 4: Pulse Modulation [5 hrs.]** Sampling theorem and its proof, PAM. **Module 5: Waveform Coding [10 hrs.]** PCM – generation, regenerative transmission, detection; Linear quantization, quantization noise, non-uniform quantization, companding; Channel noise and error probability; DM, DPCM. Line coding – types, criterions for choosing a line code, power spectra.
Text Books, and/or reference material	Text Books: 1. Principle of Communication Systems- H.Taub&D.L.Schilling (TMH). 2. Modern Digital and Analog Communication Systems- B.P.Lathi (Oxford).. Reference Books: 1. K. Sam Shanmugam, Digital and Analog Communication Systems, Wiley. 2. B. Sklar, Digital Communications, PHI. 3. S. Haykin& M. Moher, Introduction to Analog & Digital Communication, Wiley.

Mapping of CO (Course outcome) and PO (Programme Outcome) and PSO (Program Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 56				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC402	Digital Signal Processing	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT), End Assessment (EA))					
Signals and Systems (ECC303), Mathematics-II & III (MAC02, MAC331)		Class Assignments, Mid and End term examinations					

Course Outcomes	On successful completion of this course, students should have the skills and knowledge to: **CO1**. Represent signals in time and frequency domain. **CO2**. Implement DFT, FFT and z-transform. **CO3**. Analyse a given signal or system using tools such as Fourier transform and z-transform to know the property of a signal or system. **CO4**. Design of prototype of Linear Phase Filters, FIR and IIR Filter Structure. **CO5**. Process signals to make them more useful and to design a signal processor (Digital filter structures) for a given problem.
Topics Covered/ Syllabus	Module 1: Introduction, reasons behind digital processing of signals, brief historical development, organization of the course (L=2) Module 2: Theory of discrete-time linear system sequences, linear time-invariant systems, causality, stability, difference equations, frequency response, discrete Fourier series, relation between continuous and discrete systems, inverse systems, stability (L=2, T=1) Module 3: Z-transform, properties of Z-transform, system function, digital filter implementation from the system function, region of convergence in the Z-plane, determining filter coefficients from the singularity locations, geometric evolution of Z-transform in the Z-plane, relationship between Fourier transform and Z-transform, inverse Z-transform (L=4, T=1) Module 4: Fourier transform, properties of Fourier transform, inverse Fourier transform, discrete Fourier transform (DFT), properties of DFT, circular convolution, computations for evaluating the DFT, decimation in time FFT algorithm, decimation in frequency FFT algorithm, discrete Hilbert transform (L=5, T=2) Module 5: System describing equations, filter categories, all-pass filters, comb filters, direct form I and II structures, cascade and parallel communication of second-order systems, polyphase representation of filters, linear phase FIR filter structures, compensatory transfer functions, frequency sampling structure for FIR filters, test for stability using all-pass functions (L=6, T=2) Module 6: Analog filter design, analog Butterworth low-pass filter design techniques, analog Chebyshev low-pass filter, design methods to convert analog filters into digital filters, frequency

	transformation for converting low-pass filters into other types, all-pass filters for phase response compensation (L=6, T=2) Module 7: IIR realizations, all-pass realizations, FIR and IIR lattice synthesis, IIR design by bilinear transformation, digital-to-digital frequency transformation (L=6, T=2) Module 8: Windowing method for designing FIR filters, DFT method for approximating the desired unit sample response, combining DFT and window method for designing FIR filters, frequency sampling method for designing FIR filters (L=6, T=2) Module 9: Non-linear system identification schemes, fractional-order digital differentiators (DDs), digital integrators (DIs), fractional-order low-pass Butterworth filter, fractional-order low-pass Chebyshev filter (L=5, T=2)
Text Books, and/or Reference material	**Text Books**: 1. Discrete-Time Signal Processing (Second Edition), Alan V. Oppenheim, Ronald W. Schafer, and John R. Buck, Pearson Education India 2. Digital Signal Processing: Principles, Algorithms and Applications (3rd Edition), John G. Proakis, Dimitris G. Manolakis, and D Sharma, Pearson Education India 3. Richard G. Lyons, Understanding Digital Signal Processing, Prentice Hall, 1996. ISBN:0201634678. 4. 4) Digital Signal Processing by Tarun Kumar Rawat, Oxford University Press, ISBN: 9780198081937
	Reference Books/materials: 1. S. W. Smith, The Scientist and Engineer's and Guide to Digital Signal Processing, California Technical Publishing, 1997. ISBN: 0-9660176-3. 2. 2) Digital Signal Processing using MATLAB, Vinay K. Ingle, John G. Proakis, Brooks/Cole-Thomson Learning

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	2	2	1	-	-	-	-	-	-	2	3	1	1
CO#2	3	3	2	2	2	-	-	-	-	-	-	3	3	1	1
CO#3	3	3	2	3	2	-	-	-	-	-	-	3	3	3	1
CO#4	3	3	3	3	2	-	-	1	-	-	-	3	3	3	2
CO#5	3	2	3	3	2	1	-	-	-	-	-	2	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 56</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECC403</td><td>Electromagnetic Theory and Transmission Lines</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods
(Continuous (CT), Mid-Term (MT), End Assessment (EA))</td></tr>
<tr><td colspan="3">Mathematics II (MAC02), Engineering Physics (PHC01), Basic Electrical and Electronics Engineering (XEC02)</td><td colspan="5">The assessment methods comprises of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO # 1. Understanding electromagnetic theory as a basic building block of electrical communication and enhancing problem solving skills.
CO # 2. Enriching historical developments with facts that led to this theory. Emphasis on the fact that we are actually discussing Maxwell’s electromagnetic theory.
CO # 3. Enhancing theoretical knowledge from a clear viewpoint of phenomena associated when charges are at rest, charges moving with constant velocity and during acceleration/ deceleration which results in time harmonic fields.
CO # 4. Understanding underlying aspects of radio wave propagation in various media, retarded potentials and concept of radiated waves.
CO # 5. Assimilating the transmission line theory as a merger of field theory and network theory. Imbibing the fundamental aspects of Telegrapher’s equation and its essence in the analysis of transmission line parameters.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Historical foundations that led to Maxwell’s electromagnetic theory [L-2]

Electrostatics: Coulomb’s law and Field Intensity, Gauss’s law- Maxwell’s Equation, Application of Gauss’s Law, Electric Potential. Electrostatic Boundary-Value Problem: Poisson’s and Laplace’s Equations, Uniqueness Theorem, Resistance and Capacitance, Method of Images. Electric Fields In Material Space: Properties of Materials, Convection and Conduction Currents, Polarization in Dielectrics, Dielectric Constant and Strength, Continuity Equation and Relaxation Time.
[L-10; T-02]

Magnetostatic Fields: Biot-Savart’s Law, Ampere’s Circuit Law-Maxwell’s Equation, Application of Ampere’s law, Magnetic Flux Density-Maxwell’s Equation, Maxwell’s Equations for Static Fields, Magnetic Scalar and Vector Potentials, Derivation of Biot-Savart’s Law and Ampere’s Law. Magnetic Forces, Materials, and Devices:Forces due to Magnetic Fields, magnetic Torque and Moment, A Magnetic Dipole, Magnetization in Materials, Classification of Materials, Magnetic Boundary Conditions, Inductors and Inductances, Magnetic Energy, Magnetic Circuits, Force on Magnetic Materials, Analogy between Electrostatics and Magnetostatics [L-8; T-02]

Time Varying Fields, Waves, and Applications: Maxwell’s Equations:Faraday’s law, Transformer and Motional EMFs, Displacement Current, Maxwell’s Equations in Final Forms, Time-Varying Potentials, Time-harmonic Fields.[L-8; T-02]

Electromagnetic Wave Propagation: Wave Propagation in Lossy Dielectrics, Plane Waves in Lossless Dielectrics, Plane Waves in Free Space, Plane Waves in Good Conductors, Skin depth,</td></tr>
</table>

	Wave Polarization, Power and the Poynting Vector, Reflection of a Plane Wave at Oblique Incidence.**[L-8; T-02]** Transmission Lines: Introduction to different types of planar and non-planar guided media, Transmission line parameters, Telegrapher's equation, Input impedance, SWR, Power flow in transmission lines, Introduction to parallel plate and hollow metallic waveguides. Concept of mode, Waveguide design and excitation methods.**[L-10; T-02]**

Text Books, and/or reference material	**Text Book:** Matthew O H Sadiku, *Principles of Electromagnetics*, 4/e, Oxford University Press. **Reference books:** 1. E. C. Jordan and K. G. Balmain, *Electromagnetic Waves and Radiating Systems*, 2/e, PHI (Addison Wesley). 2. J. D. Ryder, "Networks, Lines and Fields", Pearson 3. David. M. Pozar, *Microwave Engineering*, 2/e, 1998 (John Wiley & Sons). 4. S. Ramo, J. R. Whinnery, and T. Van Duzer, *Fields and Waves in Communication Electronics*, 3/e, John Wiley and Sons, 1994. 5. David K. Cheng, *Field and Wave Electromagnetics*, 2/e, 1989. 6. R. E. Collin, "Foundations for Microwave Engineering", John Wiley

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

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

COURSE ARTICULATION MATRIX

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC404	Microelectronic Circuits	PCR	3	1	0	4	4
Pre-requisites		ECC-01 (Basic Electronics)					
Course Assessment methods		Continuous Assessment (CA:15%) and Mid/End-term(25%/60%)					
Course Outcomes		• **CO1: Understand** and **analyze** MOS Circuits in DC. • **CO2: Analyze** Small signal / Large Signal MOS Circuits • **CO3: Define frequency response, stability, and compensation**					

	● **CO4: Evaluate specifications from a given design/opamp.** ● **CO5: Design of single-stage opamp**.
Topics Covered	Module 1: MOS transistor characteristics; small signal model [3 hrs.] Module 2: Common source amplifier, frequency response, Miller effect [5 hrs.] Module 3: Introduction to negative feedback; Closed loop behavior of first, second, and third order systems in a feedback loop; Gain and Phase margin [7 hrs] Module 4: Dominant pole compensation; Pole splitting [3 hrs.] Module 5: Controlled sources using MOS transistors and opamps; Swing limits of amplifiers [5 hrs] Module 6: MOS Current mirrors, Active load; CMOS inverter; Differential pair [4 hrs.] Module 7: Single stage and Two-stage opamps; Miller compensation [6 hrs.] Module 8: Review of BJT [2 hrs]
Text Books, and/or reference material	**Text Books:** 1. Design of Analog CMOS Integrated Circuits, by Behzad Razavi, McGraw-Hill, 2014. 2. Adel Sedra, Kenneth C. Smith, Tony Chan Carusone, Vincent Gaudet, " Microelectronic Circuits", Oxford, 8th Ed. 2020 3. Understanding Microelectronics: A Top-Down Approach by Franco Maloberti, Wiley (2011) **Reference Books**: 1. Analysis and Design of Analog Integrated Circuit, Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, and Robert G. Meyer, John Wiley & Sons, Inc., 5th edition 2015 2. Analog MOS Integrated Circuits for Signal Processing, Roubik Gregorian, Gabor C. Temes, Wiley 1986 3. CMOS Analog Circuit Design, Phillip E. Allen and Douglas R. Holberg, Oxford University Press, 2nd edition, 2002. ISBN: 0-19-511644-5 4. Operational Amplifiers – Theory and Design, Johan H. Huijsing, Kluwer. ISBN: 0792372840 5. [5] CMOS: Circuit Design, Layout, and Simulation by R. Jacob Baker, Wiley-IEEE Press(2019)

Course Articulation Matrix (ECC404)

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

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEC431	Control Systems	PEL	2	1	0	3	3
Pre-requisites MAC01 (MATHEMATICS-I) MAC02 (MATHEMATICS-II)		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					

Course Outcomes	• CO1: To get the knowledge of basic objectives of control system design • CO2: To understand the mathematical modeling of physical systems • CO3: To understand the mathematical analysis and modeling of control techniques • CO4: To get knowledge to apply control techniques in real applications through case studies
Topics Covered	**Module 1: Introduction to control systems:** Historical development, Open and Closed loop systems, Applications, Effects of feedback, Types of feedback control systems, Servomechanism. (4) **Module 2: Mathematical Models of Physical Systems:** Modeling of electrical networks, Modeling of mechanical system elements, Transfer functions, Block diagram Algebra, Signal flow graph and Mason's Gain formula. (6) **Module 3: Introduction to State Variable Approach:** Concepts of state, state variables and state model state models for linear Continuous-time systems, state transition matrix. (4) Representation of Control Components: Electrical components, Mechanical components, Electromechanical Components. (2) **Module 4: Time domain analysis and design specification of linear systems:** Standard signals, Transient response and s-plane root locations of Second and higher order systems, Design specifications, steady state errors and error constants, effects of adding poles and zeros to transfer functions, P, PI, PD and PID controllers. (6) **Module 5: Concepts of Stability and Algebraic Criterion:** Concept of stability, Characteristic equation & necessary conditions for stability, Routh-Hurwitz stability criteria. (4) **Module 6: Root Locus Technique:** The concept of root locus, Analytical construction of Root Loci, Root locus Plots with MATLAB. (4) **Module 7: Frequency Response Analysis and Stability Studies in Frequency Domain:** Frequency domain specifications, correlation between time and frequency response, Polar plots, Bode plots, Nyquist stability criterion, Relative stability, conditionally stable system, MATLAB tools and case studies. (8) **Module 8: Design and Compensation Techniques:** Preliminary considerations of classical Design, Realization of Basic compensators, Frequency (2)
Text Books, and/or reference material	Text Books: 1. J. Nagrath and M Gopal, Control system Engineering, New Age International Publishers 2. K. Ogata, Modern Control Engineering, Prentice Hall. 3. B. C. Kuo, Automatic Control system, John Wiley & Sons Reference Books: 1. Modern Control Systems, Dorf and Bishop, Pearson 1. Norman S. Nise, Control system Engineering, John Wiley & Sons 2. B. Shahian and M. Hassul, Control System Design using MATLAB, Prentice Hall.

COURSE ARTICULATION MATRIX

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

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS451	Communication Systems Lab I	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Signals and Systems (ECC303)		CT+EA					

Course Outcomes	• **CO1:** Explain amplitude modulation in the time and frequency domains and understand corresponding circuits, signals and spectra. • **CO2:** Explain angle modulation in the time and frequency domains and understand corresponding circuits, signals and spectra. • **CO3:** Learn various pulse communication systems. • **CO4:** Understand basics of analog-to-digital conversion.
Topics Covered	1. To generate amplitude modulated wave and determine the percentage modulation. 2. To demodulate the modulated wave using an envelope detector. 3. To observe the output waveform of each block of the superheterodyne receiver. 4. To measure the modulation index in FM and show the demodulated waveform. 5. To perform pulse amplitude modulation and demodulation. 6. To generate and detect PCM signal from waveform. 7. To convert a bit stream into different line coding formats.
Text Books, and/or reference material	Text Books: 1. Principle of Communication Systems- H.Taub & D.L.Schilling (TMH). 2. Modern Digital and Analog Communication Systems- B.P.Lathi (Oxford).. Reference Books: 1. K. Sam Shanmugam, Digital and Analog Communication Systems, Wiley. 2. B. Sklar, Digital Communications, PHI. 3. S. Haykin& M. Moher, Introduction to Analog & Digital Communication, Wiley.

COURSE ARTICULATION MATRIX

Mapping of CO (Course outcome) and PO (Programme Outcome) and PSO (Program Specific Outcome)

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

CO#1	3	2	3	2	2	3	1	1	1	1	1	1	3	2	2
CO#2	2	2	2	3	2	3	2	1	1	1	2	1	2	3	3
CO#3	3	2	2	2	3	2	2	1	1	1	1	1	2	3	2
CO#4	2	3	3	3	3	2	1	1	1	2	1	2	3	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECS452</td><td>Simulation Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>2</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Signals and Systems (ECC303)
Communication Systems
Electromagnetic Fundamentals</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● CO1: Explain various modulations in the time and frequency domains and understand corresponding circuits, signals and spectra.
● CO2: Estimating BER of a communication system
● CO3: Modelling fading and noise
● CO4: Understanding the fundamentals of electromagnetic phenomena using numerical simulation and modeling
● CO5: Understanding the fundamentals of transmission lines using numerical simulation and modeling</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. To simulate different types of signals, and plot them in frequency domain. Simulating and plotting correlation, energy, and spectrum of signals.
2. To simulate random variables, AWGN, and Fading.
3. To simulate different types of modulated signals and plot them in time and frequency domains.
4. To simulate BER of a digital communication system.
5. Simulating the magnetic fields around a straight metallic wire.
6. Modeling of standing waves in a two wire transmission line.
7. Simulating the electric field and magnetic field of a two wire transmission line.
8. 8. Simulating the plane wave propagation through dielectric media.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Modern Digital and Analog Communication Systems - B.P.Lathi (Oxford)..
2. Contemporary communication systems using Matlab- Proakis and Salehi
3. Fundamentals of electromagnetics with MATLAB , Karl E. Lonngren, Sava V. Savov, Randy J. Jost., SciTech Publishing</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcomes) and PSO (Programme Specific Outcomes)

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

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS453	Microelectronic Circuits Lab	PCR	0	0	4	4	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basic knowledge of Circuits & Devices / ECC404 Microelectronic Circuits		CT+EA					

Course Outcomes	● After going through the course, student will be able to ● CO#1: Design and characterize an Amplifier ● CO#2: Draw the small signal model of the amplifier ● CO#3: Analyze Miller effect and relate its effect on pole/frequency response. ● CO#4: Difference between differential signal and a typical signal(single ended) Define CMRR, PSRR ● CO#5: Design a NAND gate from NOT gate. Interpret various Gate parameters (Noise Margin propagation delay.
Topics Covered	**List of experiments** 1. Design and characterize a BJT CE Amplifier 2. Determination of NMOS and PMOS device parameter (VT0, k',λ, γ, Subth-Slope) 3. Draw the small signal model of the amplifier and calculate the frequency responses parameter fH and fL and compare with experimental plot. 4. Analyze Miller effect by connecting a Miller capacitance between input and output and redraw its frequency response. 5. Design a Differential amplifier BJT/MOS and characterize its response (ICMR, ADM, ACM, CMRR, etc.) 6. Design the circuit of NOT Gate. Using two diodes modify the NOT gate to realize a NAND gate. Now plot the Voltage Transfer Characteristics (VTC) and measure the Noise Margins 7. With a load Cap of 10 uF, apply a square wave of 1 MHz at the input(s), and measure the propagation delay. 9. Study of Voltage Regulators (IC 723, 7809/7909)

Text Books, and/or reference material	Text Books: 1. Design of Analog CMOS Integrated Circuits, by Behzad Razavi, 2e McGraw-Hill 2. Microelectronic Circuits by Adel S. Sedra & K. C. Smith 6e OUP 2009

COURSE ARTICULATION MATRIX

Mapping of CO (Course outcome) and PO (Programme Outcomes) and PSO (Programme Specific Outcomes)

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

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

FIFTH SEMESTER

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC501	Communication Systems II	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
ECC401 (Communication Systems I)		CT+EA					

Course Outcomes	**CO1: Understand** and **analyze** systems with random signals. **CO2: Analyze** and **mitigate** interference in wired channels. **CO3: Learn** modulation techniques for wired and wireless channels. **CO4: Understand** fundamentals of information theory and coding.
Topics Covered	**Module 1: Introduction to digital communication [1 hrs.]** **Module 2: Review of random process [4 hrs.]** Basic definition, stationarity, ergodicity, autocorrelation, cross correlation, power spectral density. Response of linear systems to random inputs. **Module 3: Baseband transmission [5 hrs.]** ISI, Nyquist criterion for zero ISI, eye pattern. Mitigation of ISI – raised cosine filtering, equalization, matched filter. **Module 4: Passband transmission [10 hrs.]** Signal space representation. Binary modulations – ASK, PSK, FSK. QPSK, QAM; generation, detection (coherent/ non-coherent), power spectra, and error probability. **Module 5: Information theory and coding [10 hrs.]** Measure of information, entropy, joint and conditional entropy, self and mutual information, channel capacity and Shannon's law. Error correction coding – Noisy coding theorem, parity checking, Hamming code, CRC. **Module 6: Wireless communication [6 hrs.]** Cellular systems concepts, principles, system design fundamentals, spectrum efficiency, frequency management, channel assignment, handoff, power control. Cellular architecture and generations.
Text Books, and/or reference material	Text Books: 1. Introduction to Analog & Digital Communications - S. Haykin, M. Moher. 2. Digital Communication - J. G. Proakis, M. Salehi. 3. Wireless Communications: Principles and Practice – T. S. Rappaport. Reference Books: 1. Digital Communications - S. Haykin. 2. Modern Digital and Analog Communication Systems - B. P. Lathi, Z. Ding. 3. A First course in Digital Communications - H. H. Nguyen, E. Shwedyk. 4. Principles of Communications - R. E. Ziemer, W. H. Tranter. 5. Principles of Communication Systems - H. Taub and D. L. Schilling. 6. Digital and Analog Communication Systems - K. S. Shanmugan. 7. Digital and Analog Communication Systems - L. W. Couch. 8. Digital Communications - B. Sklar. 9. Theory and Design of Digital Communication Systems - T. T. Ha.

COURSE ARTICULATION MATRIX

Mapping of CO (Course outcome) and PO (Programme Outcome) and PSO (Program Specific Outcome)

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

CO#3	3	2	2	2	3	2	2	1	1	1	1	1	2	3	2
CO#4	2	3	3	3	3	2	1	1	1	2	1	2	3	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC502	Computer Organization and Architecture	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Digital Circuits and Systems (ECC402), Microprocessors and Microcontrollers (ECC503).		CT+EA					

Course Outcomes	Upon successful completion of this course, students will - ● CO 1: Acquire ideas about computer architecture and organisation. ● CO 2: Understand the fundamental concepts of ISA. ● CO 3: Illustrate the operations of the memory unit. ● CO 4: Analyzethe control and data flow of a computer. ● CO 5: Design and implementation of multiprocessors. ● CO 6: Evaluate the performance of a computer system
Topics Covered	**Module 1: Introduction [L - 4]** Defining Computer Architecture, Flynn's Classification of Computers, Metrics for Performance Measurement, Von Neumann Architecture vs. Harvard Architecture, Introduction to Instruction Set Architecture (ISA), Examples of different architectures, Introduction to memory hierarchy, Basic concepts of Compiler and Interpreter, Semantics of Assembly language, Stored program computing, Instruction and Machine cycle, RTL activities, Organization of CPU registers **Module II: Instruction Set Architecture (ISA) [L – 5]** Fundamental concepts of ISA: Definition and Importance of ISA, Von Neumann model and data flow model, ISA principles and trade-off, elements of an ISA, RISC vs. CISC, MIPS ISA, ISA vs. microarchitecture level trade-off, property of ISA vs. microarchitecture, Classification of ISA: Two styles of CPU design – RISC vs CISC. **Module III: Arithmetic Operations [L – 5]** Binary arithmetic, ALU Design, multiplier design, divider design, fast addition, multiplication, Fixed and floating-point representation (IEEE-754 standard) and arithmetic. **Module IV: Processor Design [L – 8]** Single-cycle microarchitecture, multi-cycle microarchitecture, microprogrammed microarchitecture, pipelining: issues in pipelining, data and control dependence handling, branch prediction, precise exceptions, state maintenance, state recovery; Out-of-Order execution and issues in OoO execution. **Module V: SIMD, GPUs, VLEW and DAE [L – 4]** SIMD processing: array and vector processors, SIMD operation in modern ISAs, VLIW, Decoupled Access Execute (DAE), Systolic Array. **Module VI. Memory Hierarchy and Caches [L - 7]** Memory hierarchy, physical memory and virtual memory, emerging memory technologies, main memory, memory controller, memory management, memory latency tolerance:

	prefetching, Cache organisation and operation, high-performance caches, memory consistency, cache coherence, in-memory processing. **Module VII: Multiprocessor [L – 5]** Multiprocessor types, multiprocessing, issues in multiprocessor, limits of parallel speedup, difficulty in parallel programming, heterogeneous systems, input/output subsystem, interfaces, I/O operations, interconnection networks: bus-based and NoC-based architectures. **Module VIII: Instruction, Thread, and Data Level Parallelism [L – 6]** **Part A:** Instruction-level Parallelism (ILP): Concepts and Challenges, Basic Compiler Techniques for Exposing ILP, Reducing Branch Costs with Advanced Branch Prediction, Dynamic Scheduling, Limitations of ILP, Multithreading: Exploiting Thread-Level Parallelism to Improve Uniprocessor Throughput, Shared-Memory Multicore Systems. **Part B:** Performance Metrics for Shared-Memory Multicore Systems, Cache Coherence Protocols, Vector Architecture, SIMD Instruction Set Extensions for Multimedia, Graphics Processing Units, GPU Memory Hierarchy, Detecting and Enhancing Loop- Level Parallelism, CUDA Programming, Case Study: Nvidia Maxwell.
Text Books, and/or reference material	**Text Books:** 1. Patterson and Hennessy, "Computer Organization and Design: The Hardware/Software Interface", 4th Edition, Morgan Kaufmann/ Elsevier, 2009. 2. W. Stallings, "Computer architecture and organization: Designing for Performance" Pearson Education; 9th edition (1 January 2013) **Reference Books:** 1. Andrew Tanenbaum, "Structured Computer Organization"6th Ed, Pearson, 2016. 2. Patt and Patel, "Introduction to Computing Systems: From Bits and Gates to C and Beyond", Morgan Kaufman, Elsevier, 2th Edition, McGraw-Hill Education 2003. 3. Harvey Cragon, "Computer Architecture and Implementation", Cambridge University Press, 2000. 4. C. Hamacher, Z. Vranesic, S. Zaky, "Computer Organization", McGraw Hill Education; 5th Edition, 2011.

COURSE ARTICULATION MATRIX

Mapping of CO (Course outcome) and PO (Programme Outcome) and PSO (Program Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 56				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC503	Microcontrollers and Embedded Systems	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods: (Continuous (CT), Mid-semester assessment (MA) and End Assessment (EA)):					
Digital Circuits and Systems (ECC402)		CT+MT+EA					

Course Outcomes	At the end of the course, a student will be able to: **CO1 Describe** the fundamental operations and internal architectures of microprocessors and Microcontroller's as well as **identify** the peripherals to be used for the given problems on Embedded Systems. **CO2 Understand** Microcontroller based systems and **select** appropriate platform to meet specified requirements. **CO3 Apply** the knowledge of Microprocessors, Microcontrollers and peripheral devices and demonstrate the programming proficiency and provide solutions to the real-world problems. **CO4 Design** necessary I/O and Memory interfacing circuitry to communicate Microcontroller with external devices.
Topics Covered	**Module – I:** [L-3, T-1] **Introduction to Microprocessors (MPs), Microcontrollers (MCs) and Embedded Systems (ESs):** Basic computer architecture, stored program computer concept; Evolution of Microprocessors (MPs), 8085 Architecture, drawbacks, Architecture of 8086: and 8088; Brief description of 80186, 80386, RISC. Introduction to Microcontroller (MC), comparison between microprocessors & microcontrollers; Introduction to Embedded Systems (ESs), Embedded Systems and Co-design Issues, Processor embedded into a system, Hardware and software in ES, Examples of ES, use of VLSI circuit design Technology and software tools for development of ES. **Module – II:** [L-4] **Architecture of Microcontroller 8051:** Hardware, Oscillator and clock program counter, pin configuration and functions, timing and machine cycles, I/O Ports, registers – program counter, data pointer, stack and stack pointer, special function registers, Memory Organization, Program memory, data memory, counters and timers, serial data input and output Interrupts, connection of external memory, Interfacing of 8051 with EPROM. **Module – III:** **Assembly language programming of 8051:** Structure of Assembly Language, Assembling and running a program in 8051, Addressing Modes - immediate, registers, direct and indirect data movement and Exchange instructions, Accessing memory using various addressing modes, Instruction set and instruction classifications - push and pop up-codes, arithmetic and logic instructions, bit level Operations, jump and call instructions. Input/output port programming, programming timers, Asynchronous serial data communication, timer and hardware interrupt service routines, Programming Timer Interrupts, Programming External Hardware Interrupts, Programming the Serial Communication Interrupts, Timer/Counter programming for time delay generation and waveform generation. **Module IV:** **Interfacing 8051:** External memory and memory address decoding, memory mapped I/O, time delay subroutine look up table implementation, interfacing matrix keyboard and seven

	segment displays through scanning and interrupt driven programs, interfacing ADC and DAC. Interfacing of LCD display. **Module – V:** **Embedded Systems** - Introduction to Embedded Systems, The build process for embedded systems, embedded systems and their characteristics and typical hardware components, Software Embedded into a system, Processor and Memory organization, Structural Units in a processor, Processor Selection for an embedded system, Memory Devices, Memory selection for an embedded system, Allocation of Memory to program segments and blocks and memory map of a system, Direct Memory access, Interfacing processor, memories and I/O devices **Module – VI.** **Arduino:** Introduction to the Arduino, creating an Arduino programming Environment, Arduino IDE, creating an Arduino program, Arduino Libraries, Analog and Digital Interfacing, Adding Interrupts, communicating with devices and sensors. **Module – VII**. **Raspberry Pi:** Introduction to the Raspberry Pi, basic functionality of the Raspberry Pi board and its processor, setting and configuring the board, programming on Raspberry Pi, python programming environment, python expressions, general purpose IO pins, Protocol pins, RPi, GPIO library, communicating with devices and sensors. **Module –VIII**. **IoT application using Arduino and Raspberry Pi:** Arduino- Playing tones and a melody, alphanumeric LCD display, speed and direction control, temperature and humidity sensor interfacing. Raspberry Pi-controlling LED, interfacing an LED and Switch, Interfacing a Light Sensor (LDR), camera interfacing etc. **Total Lecture: 45**
Text Books, and/or reference material	**Text Books** 1. Microprocessor, Architecture, Programming and Applications with Microprocessor 8085;Author: Ramesh S. Gaonkar (5th Edition); Publisher – Prentice Hall 2. The 8051 Microcontroller and Embedded Systems by Muhammad Ali Mazidi, Janice G. Mazidi, Rolin D. McKinlay, Pearson Education. 3. Embedded systems-architecture, programming and design, (Rajkamal) Tata McGraw Hill. 4. Arduino Cookbook; Authors: Michael Margolis, Publisher: O'Reilly Media, Inc, 5. "Raspberry Pi User Guide", Eben Upton and Gareth Halfacree, August 2016, 4th Edition, John Wiley &Sons. 6. An Embedded Software Primer (David E. Simon) Pearson Education **References:** 1. Advanced Microprocessors and Peripherals, Authors: A. K. Ray, K. M. Bhurchandi; Publisher - Tata McGraw Hill. 2. Microprocessors and Interfacing: Programming and Hardware; Authors: Douglas V. HallPublisher - Tata McGraw Hill 3. The Intel Microprocessors – Architecture, Programming and Interfacing; Authors: Barry B. Brey; Publisher: Pearson Education 4. The 8051 Microcontroller, Kenneth. J. Ayala, Cengage Learning, 3rd Ed. 5. The 8051 Microcontroller: A Systems Approach; Authors: M.A. Mazidi, R.D. McKinlay, J.G. Mazidi; Publisher- Pearson. 6. Embedded microcontroller and processor design; Authors: G. Osborn; Publisher: Pearson 7. "Programming with Raspberry Pi: Getting Started with Python", Simon Monk, January 2012, McGrawHill Professional. 8. "Arduino for beginners: Essential Skills Every Maker Needs", John Baichtal, Person

	Education, Inc., 1st Edition. 9. Embedded Microcomputer Systems Real time Interfacing Valvano

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC504	Artificial Intelligence and Machine Learning	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods: Continuous (CT), mid-term (MT), and End Assessment (EA)					
Introduction to Computing (CSC01), Computer Programming Languages like Python, C++, Matlab etc.		CT+MT+EA					
Course Outcomes	After the completion of the course the student will be able to learn the following: CO1: Distinguish between, supervised, unsupervised and semi-supervised learning CO2: Apply the apt machine learning strategy for any given problem CO3: Implement various ways of selecting suitable model parameters for different machine learning techniques CO4: Modify existing machine learning algorithms to improve classification efficiency CO5: Solve problems associated with batch learning and online learning, and the big data characteristics such as high dimensionality, dynamically growing data and in particular scalability issues. CO6: Study of various machine learning algorithms including deep learning						
Topics Covered	**MODULE I INTRODUCTION [L=3]** Brief Introduction to Machine Learning, Supervised Learning ,Unsupervised Learning, Reinforcement Learning Design a Learning System, Perspectives and Issues in Machine Learning ,Concept Learning **MODULE II REGRESSION [L=6]**						

	Linear Algebra, Statistical Decision Theory, Regression & Classification, Bias – Variance, Linear Regression, Multivariate Regression **MODULE III NEURAL NETWORKS AND SUPPORT VECTOR MACHINE [L=8]** Multi-layer Perceptron , Training of Multi -layer feed forward neural network using back propagation algorithm ,Over-fitting of trained model, Radial Basis Functions neural network, Support Vector Machines **MODULE IV TREE AND UNSUPERVISED LEARNING [L=7]** Learning with Trees , Decision Trees , Constructing Decision Trees ,Classification and Regression Trees , Unsupervised Learning, Gaussian Mixture Models, K-means clustering Algorithm **MODULE V DIMENSIONALITY REDUCTION [L=6]** Dimensionality Reduction, Linear Discriminant Analysis, Principal Component Analysis **MODULE VI STUDY OF MACHINE LEARNING ALGORITHMS [L=12]** Extreme learning machine (ELM), Training and testing of ELM, Recurrent Neural Network(RNN) and long short-term memory (LSTM),Training a LSTM based RNN, Reinforcement Learning, Deep learning and Convolutional Neural Network(CNN).
Text Books, and/or Reference material	**Text Books**: 1. Stephen Marsland, "Machine Learning – An Algorithmic Perspective", Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014. 2. Tom M Mitchell, "Machine Learning", First Edition, McGraw Hill Education, 2013. 3. 3.Satish Kumar, " Neural Networks: A Classroom Approach", McGraw-Hill (India), 2013 4. 4.Shai Shalev-Shwartz and Shai Ben-David, "Understanding Machine Learning: From Theory to Algorithms, "Cambridge University Press",2014
	Reference Books: 1. Peter Flach, "Machine Learning: The Art and Science of Algorithms that Make Sense of Data", First Edition, Cambridge University Press, 2012. 2. Jason Bell, "Machine learning – Hands on for Developers and Technical Professionals", First Edition, Wiley, 2014 3. Ethem Alpaydin, —Introduction to Machine Learning 3e (Adaptive Computation and Machine Learning Series), Third Edition, MIT Press, 2014 4. 4.Simon Haykin, "Neural networks and learning machines," Pearson,3rd edition,2009 5. 5.Charu C.Aggarwal, "Neural Networks and Deep learning,"Springer,2018

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) & PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	2	1	1	2	1	1	1	1	1	1	2	3	2
CO#2	3	3	3	2	2	2	1	1	1	1	1	1	3	2	2
CO#3	3	3	2	2	2	1	2	1	1	1	1	1	3	3	2
CO#4	3	2	2	3	3	2	1	1	1	1	1	1	3	3	2
CO#5	3	2	2	2	2	2	1	1	1	1	1	1	3	2	2
CO#6	3	3	2	2	2	2	1	2	1	1	1	2	3	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS551	Communication Systems Lab II	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Communication Systems I (ECC401)		CT+EA					
Course Outcomes	**CO1: Understand** simultaneous transmission of digital signals. **CO2: Learn** modulation techniques for wired and wireless channels. **CO3: Analyze** interference in wired channels. **CO4: Design** hardware for communication systems.						
Topics Covered	1. Time division multiplexing (TDM) 2. Amplitude shift keying (ASK) - Generation and detection 3. Phase shift keying (PSK) - Generation and detection 4. Frequency shift keying (FSK) - Generation and detection 5. To observe CW modulated waveforms in time domain and frequency domain in MATLAB platform. 6. To observe the effect of ISI and AWGN using eye pattern in MATLAB platform. 7. To design transmitter and receiver circuit for amplitude/ frequency modulation using discrete components.						
Text Books, and/or reference material	Text Books: 1. Introduction to Analog & Digital Communications - S. Haykin, M. Moher. 2. Digital Communication - J. G. Proakis, M. Salehi. 3. Wireless Communications: Principles and Practice – T. S. Rappaport. Reference Books: 1. Digital Communications - S. Haykin. 2. Modern Digital and Analog Communication Systems - B. P. Lathi, Z. Ding. 3. A First course in Digital Communications - H. H. Nguyen, E. Shwedyk. 4. Principles of Communications - R. E. Ziemer, W. H. Tranter. 5. Principles of Communication Systems - H. Taub and D. L. Schilling. 6. Digital and Analog Communication Systems - K. S. Shanmugan. 7. Digital and Analog Communication Systems - L. W. Couch. 8. Digital Communications - B. Sklar. 9. Theory and Design of Digital Communication Systems - T. T. Ha.						

COURSE ARTICULATION MATRIX

Mapping of CO (Course outcome) and PO (Programme Outcome) and PSO (Program Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 30				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS552	Digital Signal Processing Lab	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MATLAB, Signals & Systems (ECC303)		Quizzes and Lab Assessments					

Course Outcomes

On completion of the experiments conducted, students will be able to:

CO#1: Generate different types of digital signals
CO#2: Sampling, reconstruction, linear and circular convolution between signals
CO#3: Simulate impulse response of systems from difference equations
CO#4: Study the frequency response of LTI systems
CO#5: Carry out Discrete Fourier Transform and Fast Fourier Transform
CO#6: Design different Digital Filters

Topics Covered/ Syllabus

A. Introduction to digital signals and systems:

Experiment 1:

Generate and plot the following sequences:

i. Unit sample sequence
ii. Unit step sequence
iii. Unit ramp sequence
iv. Real valued exponential sequence $x(n)=(0.8)^n u(n); 0 \le n \le 50$
v. Square wave and Sawtooth wave sequence of length 50, having peak amplitude 5.

Experiment 2:

a) Generate a 50 Hz continuous time sinusoidal signal $x(t)=A\cos(2\pi ft)$ having frequency of 50 Hz and its sampled version with sampling frequency 1000 Hz. Assume the amplitude as 5.

b) Write a program to generate a signal $x(n)=u(n)-u(n-10)$. Also plot the even and odd component of the signal.

B. Sampling, reconstruction and convolution of signals:

Experiment 3:

Consider an analog signal $x(t)=\sin(20\pi t); 0 \le t \le 1$. It is sampled at sampling time interval (T_s) as 0.01 second to obtain $x(nT_s)$. Reconstruct the analog signal from the sampled signal using *sinc* interpolation.

Experiment 4:

a) Evaluate the convolution sum for a system whose impulse response $h(n)$ and input $x(n)$ are same and are described as:

$$x(n)=h(n)=\left[u(n+N)-u(n-N-1)\right]$$

b) Find the linear convolution of the following signals:

$x(n)=\{2,1,3,5,9\}$ $\quad h(n)=\{5,5,8,9,2\}$

$\uparrow$ and $\uparrow$

c) Write down a program to compute the correlation of the following sequence.

$x(n)=\{1,4,1,3\}$

$\uparrow$

C. Difference equation and impulse response:

Experiment 5:

a) Find the impulse response of the following system: y(n) -0.6y(n-1) +0.08y(n-2) = x(n)

b) Find the step response of the system y(n)=0.7y(n-1)-0.12y(n-2)+x(n-1)+x(n-2) with the initial condition y(-1)=1,y(-2)=1.

c) An LTI system is specified by the difference equation y(n) = 0.8y(n-1) + x(n) Determine H(e^{jw}). Also calculate and plot the steady state response for the input x(n) = cos(0.05πn)u(n)

D. Frequency domain transforms:

Experiment 6:

d) A symmetrical rectangular pulse is given by

$x(n)=1; -N\le n\le N$

0; otherwise

Determine the DTFT for N=2, 5, 10, 15. Scale the DTFT so that $X\left(e^{j0}\right)=1$.

Plot the normalized magnitude response of the DTFT over $[-\pi,\pi]$, Study these plot and comment on their as a function of N.

e) Determine and plot the DTFT of a sinusoidal signal

$x(n)=\cos\left(\frac{\pi n}{4}\right); 0\le n\le 100$. Also investigate the periodicity.

Experiment 7:

a) A discrete time LTI system is represented by a first order difference equation

$y(n)=ay(n-1)+x(n); n\ge 0$

where $x(n)$ is the input of the system and $y(n)$ is the corresponding output.

For an input $x(n)=u(n)-u(n-1)$, zero initial condition and $a=0.8$, find and plot $y(n)$.

Given a causal system $y(n)=0.9y(n-1)+x(n)$, find $H(z)$ and plot its poles and zeros. Also plot the frequency response $\left|H\left(e^{jw}\right)\right|$ and $\angle H\left(e^{jw}\right)$.

E. Discrete Fourier Transform and Fast Fourier Transform:

Experiment 8:

a) Consider a 9-point sequence $x(n)=\{1,2,3,4,5,6,7,8,9\}$. Determine and plot the sequences $x\langle\langle n-3\rangle_9\rangle$ and $x\langle\langle n+3\rangle_9\rangle$.

b) Let $x_1(n)=\{1,2,2,1\}$ and $x_2(n)=\{1,2,3,4\}$ .Write a program to perform 4-point circular convolution of these two signals. Also find the linear convolution

	of these two signals using circular convolution. **Experiment 9:** Compute the output of a linear filter described by impulse response $h(n)=\{1,2,3,1,2\}$ and input $x(n)=\{1,1,1,1\}$ using fft command. ***F. Digital Filters:*** **Experiment 10:** a) For the desired frequency response $H_d\left(e^{j\omega}\right)=e^{-j\omega\tau};\omega_{c1}\le\lvert\omega\rvert\le\omega_{c2}$ $0;\lvert\omega\rvert<\omega_{c1},\omega_{c2}<\lvert\omega\rvert\le\pi$ Determine $H\left(e^{j\omega}\right)$ for M=35 using Blackman window if $\omega_{c1}=\frac{\pi}{4}$ and $\omega_{c2}=\frac{\pi}{2}$. b) Implement type 1, 2, 3, 4 linear phase FIR filter. **Experiment 11:** a) Write a MATLAB program to design an IIR low pass Butterworth filter using the impulse invariant method for the following specifications: $0.8\le\left\lvert H\left(e^{j\omega}\right)\right\rvert\le 1;\lvert\omega\rvert\le 0.2\pi$ $\left\lvert H\left(e^{j\omega}\right)\right\rvert\le 0.2;0.6\pi\le\lvert\omega\rvert\le\pi$ Assume T=1 second. b) Write a MATLAB program to design a digital low pass Butterworth filter to satisfy the following specifications: Pass band cutoff=0.2π, pass band attenuation= 7 dB, stop band cutoff= 0.3π, stop band attenuation= 16 dB using Bilinear Transformation method. Assume T= 1 second.
Text Books, and/or Reference material	**Text Books:** 1) Discrete-Time Signal Processing (Second Edition), Alan V. Oppenheim, Ronald W. Schafer, and John R. Buck, Pearson Education India 2) Digital Signal Processing by Tarun Kumar Rawat, Oxford University Press, ISBN: 9780198081937
	Reference Books/Materials: 1) Digital Signal Processing using MATLAB, Vinay K. Ingle, John G. Proakis, Brooks/Cole-Thomson Learning

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	2	2	-	-	-	-	-	1	-	2	3	1	1
CO#2	3	3	3	2	-	-	-	-	-	1	-	1	3	1	1
CO#3	3	3	2	3	2	-	-	-	-	1	-	1	3	3	1

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 30				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS553	Microcontrollers and Embedded Systems Laboratory	PCR	0	0	3	3	1.5

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Digital Circuits and Systems (ECC402)	Day to day evaluation during the laboratory session and End Semester Examination

Course Outcomes

At the end of this sessional course, a student will be able to:

CO # 1. **Recognize** the different parts of Microprocessors, Microcontrollers and peripheral devices.

CO # 2. **Interpret** methodologies to be adopted for the specified problems on Microprocessors and Microcontrollers.

CO # 3. **Apply** appropriate instruction codes to develop the program for Arithmetic, logical, data transfer and copying operations as well as data communication to external devices.

CO # 4. **Analyze** requirements of experimental setup of using Microprocessor and Microcontroller.

CO # 5. **Construct** the necessary interfacing circuitry to communicate Microprocessor and Microcontroller with the external devices.

List of Experiments

Part A: Programing using Microcontroller 8051 Kit and simulator

1. Perform the following arithmetic operations of two 16 bit nos.
   a) Addition. b) Subtraction, c) Multiplication, d) Division.
2. Exchange the contents of two memory locations.
3. Determination of the sum of first n natural nos. using 8051 Microcontroller.
4. Check whether given number is palindrome or not.
5. Determination of the largest and smallest no. of a data array.
6. Sorting the data array as follows
   a) Ascending order.
   b) Descending order.
7. Perform the following conversions of the number system
   a) BCD to ASCII.
   b) ASCII to Decimal.
   c) Decimal to ASCII.
8. Generation of 1 second delay continuously using on-chip timer.
9. Interfacing with stepper motor.
10. Interfacing with LCD.
11. Display “Hello World” message using Internal UART.
12. Determine Digital output for a given Analog input using Internal ADC of Microcontroller.
13. Interface a DAC and generate Triangular and Square waveforms.
14. Interface a 4x4 keyboard and display the key code on an LCD.
15. Demonstrate the use of an external interrupt to toggle an LED On/Off.

	16. Display the Hex digits 0 to F on a 7-segment LED interface, with an appropriate delay. **Part B: Programming on ARDUINO Microcontroller Board** 17. Wi-Fi communication 18. Zig Bee communication and IoT demo
Text Books, and/or reference material	**Text Books** [T1]. Lab. instruction manual and operation manuals supplied by the manufacturers. [T2]. Microprocessor Architecture, Programming and Applications with the 8085; Authors: R. Gaonkar; Publisher -, Prentice Hall. [T3]. Advanced Microprocessors and Peripherals, Authors: A. K. Ray, K. M. Bhurchandi; Publisher Microprocessors and Interfacing: Programming and Hardware; Authors: Douglas V. HallPublisher - Tata McGraw Hill. [T4]. The 8051 Microcontroller and Embedded Systems by Muhammad Ali Mazidi, Janice G. Mazidi, Rolin D. McKinlay, Pearson Education. [T5]. The 8051 Microcontroller: A Systems Approach; Authors: M.A. Mazidi, R.D. McKinlay, J.G. Mazidi; Publisher- Pearson.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Fifth Semester Department Electives

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE510	Object Oriented Programming	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), Mid-Term (MT), End Assessment (EA))
Computer Programming (CSC01)	The assessment methods consist of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.

Course Outcomes	CO1: **Implement** programs using classes and objects CO2: **Specify** the forms of inheritance and use them in programs CO3: **Analyze** polymorphic behavior of objects CO4: **Introduce** Templates and Exception Handling CO5: **Design** and write programs using an object oriented language CO6: **Apply** object oriented approach to design software
Topics Covered	**Overview- [3L]** Programming in general; Programming paradigms-Procedural, Functional, Logic and Object Oriented; Basics of Object Oriented Programming; Available Object Oriented Languages; Program Compilation; Object Oriented Programming Terms – Class, Object, Encapsulation, Abstraction, Polymorphism, Inheritance, Static and Dynamic Binding. **Revisiting Array, Pointer and Structure** – **[2L]** Defining arrays and accessing array elements; Array initialization and assigning values to array elements; Multidimensional arrays; Addresses and Pointers; Void pointer, address-of and indirection operator; Pointer to pointers; Difference of Pointer and Array; Pointer arithmetic; Defining structures **Revisiting Functions- [2L]** Declaration, definition and call of a function; Inline functions; Main function arguments; Reference variables; Function overloading; Parameter passing concepts- call by value vs. call by reference; Concept of recursion; Scopes of variables; Return from functions by value as well as by reference; Pointer to functions. **Data Abstraction through Classes and User Defined Data Types- [4L]**C-struct and defining user defined data types through typedef; Class, Object, and members of a class; Constructor and Destructor; Dynamic memory management using *new* and *delete* operator (C++) or *malloc* and *free* (C-way); *this* operator; Static members of a class; Additional scope of variables. **Operator Overloading- [4L]** Operator overloading techniques and restrictions; Overloading unary and binary operators; Overloading function operator, index operator, class member access, and cast operator; User defined conversions through constructors or cast operators; Overloaded non-member operators outside the class; Overloading *new* and *delete* operators. **Class Relationships** – **[4L]** The concept of inheritance- single and multiple; Constructor and Destructor calling sequences; Virtual base class; Accessibility in friends and derived classes; Virtual

	function and operator; Linking C file in C++ program. **Advanced Concepts – [4L]** Concept of template- class and function templates; Namespace; Need and mechanism of exception handling; Advanced cast operators- *static_cast*, *dynamic_cast*, *reinterpret_cast*, and *const_cast*; *typeid* operator **Standard Library in C++ - [4L]** Standard C++ library functions for input and output handling; Standard Template Library **Data Structures and Applications in C++ - [4L]** Several fundamentally used data structures as array and linked list where from other data structures like stack, queue, tree, can be made **Object Oriented Design and Modelling** – **[4L]** Software development process from software engineering and quality perspective; Software architecture concepts; Best practices of software development; Phases of software development- inception, elaboration, construction, and transition; Object Oriented principles and concepts; Object Oriented modelling from views of Booch, Rumbaugh, Jacobson **Unified Modelling Language – [4L]** Basic building blocks of UML; Use case and actors; Structural and behavioural modelling aspects; Packaging and deployment; Software development process through UML. **Laboratory Workouts** – [**3L**]
Text Books, and/or reference material	**Text Books**: 1. Bjarne Stroustrup "The C++ Programming Language", Pearson Education 2. Debasish Jana, "C++ and Object Oriented Programming Paradigm", Prentice Hall of India Pvt. Ltd. **Reference Books**: 1. Bruce Eckel, "Thinking in C++", Prentice Hall 2. S. B. Lippman, J. Lajoie, B. E. Moo, "C++ Primer", Addison-Wesley Professional 3. Bjarne Stroustrup, "Programming: Principles and Practice Using C++", Addison-Wesley Professional 4. Effective C++: 50 Specific Ways to Improve Your Programs and Design by Scott Meyers, 1997

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	1	1	1	1	1	2	1	3
CO2	2	3	2	3	1	1	1	1	1	2	1	3
CO3	2	3	2	3	1	1	2	1	1	1	1	3
CO4	3	2	2	2	1	1	2	1	1	1	1	3
CO5	3	3	3	3	1	1	2	1	2	3	1	3
CO6	3	2	3	3	3	1	2	1	2	3	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE511	Probability and Random Signal Theory	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), Mid-Term (MT), End Assessment (EA))
NIL	CT+MT+EA

Course Outcomes	CO1: Characterize probability models and function of random variables. CO2: Evaluate and apply moments, ACF, PSD & characteristic functions and understand the concept of inequalities and probabilistic limits. CO3: Recognize, interpret and apply a variety of deterministic and nondeterministic random processes that occur in engineering.
Topics Covered	1. Introduction: Basic of Probability theory, Bernoulli's Trials (5L) 2. Random Variables: types, examples, PDF, PMF, Conditional probability density function, (10L). 3. Function of one random variable. (4L) 4. Mean, Variance, Moments, Characteristics functions of random variables (5L) 5. Two random variables, Joint density and distribution function, one function of two random variables, Two functions of two random variables (8L) 6. Random processes: definitions and notations, Autocorrelation function, Cross correlation function, Covariance, PSD, Markov Processes, Gaussian Process, Poisson Process, Systems and random signals (10L)
Text Books, and/or reference material	**Text Books**: 1. A. Popoulis, U. Pillai, *Probability, random variables and stochastic processes*, Tata McGraw-Hill Inc., 4th Ed., New Delhi, 2017 2. K. Sam Shanmugam, *Digital and analog communication systems*, Wiley, India, 2011. 3. P. Peebles, *Probability, random variables and random signal priniciples*, McGraw-Hill Inc., 4th Ed., New York, USA, 2001 4. C. W. Therrien, M. Tummala, *Probabilty and random processes for electrical and computer engineers*, 2nd Ed., CRC press, printed in India, 2012 **Reference Books**: 1. George R. Cooper, C. D. McGillem, *Probabilistic methods of signal analysis and system analysis*, Oxford University Press, 3rd Ed. , New Delhi, 2007 2. Alberto Leon-Garcia, *Probability and random processes for electrical engineering*, Pearson Education Inc., 2nd Ed., 2007

COURSE ARTICULATION MATRIX

Mapping the Course Outcome (CO) to Programme Outcome (PO) and Programme Specific Outcome (PSO)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	2	2	1	1	1	-	1	1	2	3	3	1	2
CO#2	3	2	2	2	2	-	-	-	-	1	1	1	3	2	2
CO#3	3	2	2	3	2	-	-	-	-	-	-	1	3	2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 44				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE512	Data Communication and Computer Networks	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and End Assessment (EA))
Communication Systems I (ECC401) and Communication Systems II (ECC501)	The assessment methods consist of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.

Course Outcomes	CO1: **Understand** the rudiments of how computers communicate CO2: **Acquaintance** with the architecture of a number of different networks CO3: **Understand** the principles of protocol layering CO4: **Understand** the basic aspects of packet based protocol design and implementation CO5: **Analyze** and **Explain** the information flow in network traffic CO6: **Interpret** the importance of interconnection networks
Topics Covered	**Course Introduction and Physical Layer – [4L]** Data communication; Networks; Protocols and standards; Layered tasks; OSI Model; TCP/IP protocol suite; Addressing; Physical layer and media; Data and Signals; Analog and Digital; Transmission impairment; Line coding; Block coding; Sampling; Modulation of digital data; Telephone modems; Modulation of Analog signals; FDM,WDM,TDM, Guided media; Unguided media; Circuit switching; Telephone networks; DSL technology; Cable modem; SONET. **Data Link Layer, Framing, and Error Handling – [8L]** Types of errors; Error detection; Error correction; Flow and error control; Stop and wait ARQ, go back N ARQ, Selective Repeat ARQ; HDLC; Point to Point protocol; random access; Controlled access; Traditional Ethernet; Fast Ethernet; Gigabit Ethernet; IEEE802.11; Bluetooth; Backbone network; Virtual LAN; Cellular Telephony; Satellite Networks; Virtual Circuit switching; Frame relay; ATM. **Queuing Analysis in Communication Networks – [10L]** Introduction to queuing models; Little's theorem; M/M/1,M/M/m queues; Networks of queues; M/G/1 queues; M/G/1 queues with occupancy distribution; M/G/1 queues with vacations, reservations, Priority queues; Stability of queuing systems; Multiple access and ALOHA; Stabilized ALOHA; Tree algorithms; CSMA, CSMA/CD and Ethernet **Network Layer Concepts – [5L]** Internetworks; Addressing; Routing; ARP; IP; ICMP; IPV6. **Transport Layer Concepts – [5L]** Process to process delivery; User Datagram Protocol (UDP); Transmission Control Protocol (TCP); Data traffic; Congestion control; Quality of Service(QoS); Integrated services; Differentiated services; QoS in switched networks **Routing and Flow Control – [8L]** High speed LANs; Token rings; Introduction to Switch Architecture; High speed switch scheduling; Broadcast routing and spanning trees; Shortest path routing; Distributed routing algorithms; Optimal routing; Flow control window/credit schemes; Flow control rate based schemes; ATM networks. **Application Layer, WWW and HTTP – [4L]** Domain Name System, Dynamic Domain Name System; Encapsulation; Remote Logging;

	Electronic mail and File transfer; HTTP architecture; Simple Network Management Protocol (SNMP); Multimedia; Digitizing Audio and Video; Audio and Video compression; Streaming stored Audio/Video; Streaming live Audio/Video; Real time interactive Audio/Video; RTP; RTCP; Voice over IP.
Text Books, and/or reference material	**Text Books**: 1. Ferouzan, Behrouz A., "Data Communications and Networking", TMH. 2. William Stallings, "Data and Computer Communication", Pearson Education. 3. Bertsekas, Dimitri, and Robert Gallager, "Data Networks", Upper Saddle River, NJ: Prentice Hall **Reference Books**: 1. Tanenbaum , A.S., "Computer Networks", Upper Saddle River, NJ: Prentice Hall 2. Black, Ulylers D., "Data Communication and Distributed Networks", PHI.

COURSE ARTICULATION MATRIX

Mapping CO (Course outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE513	Mobile Computing	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Communication Systems I (ECC401) and Communication Systems II (ECC501)		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes		● CO1: Introduce to the basic of Wireless Networks. ● CO2: Preparing the right background to take up research works in emerging wireless technologies and Internet of Things. ● CO3: To introduce the scopes of using sensing, edge computing, Machine learning mechanisms in pervasive cyber physical systems. ● CO4: Able to understand the innovation opportunity in IoT application segments. ● CO5: Hands-on experience on Wireless Networks & Mobile Computing.					
Topics Covered		**Module 1:** Physical Layer **(6 Hours)** Bit transmission over Wireless, Vary Much different from Wired Network.					

	Module 2: Mac Layer **(8 Hours)** Access in Shared Medium, Difference between Wired MAC & Wireless MAC, Different Type of MACs (a) Random MAC (b) Scheduled MAC, Examples of MAC Implementation (WiFi Protocol --802.11, Bluetooth Protocol--805.15). **Module 3:** Network Layer **(8 Hours)** Reactive Routing, Proactive Routing, DSR Principle, AODV Principle, Location Aware Routing. Adhoc Network, Delay Tolerant Network, Opportunistic Network Introduction, Architecture & Applications, Routing Algorithms – Epidemic, Prophet, Spray & Wait, Spray & Focus, Maxprop Simulation Tool - ONE Simulator. **Module 4:** Transport Layer **(8 Hours)** Wireless TCP and rationale, Difference between Wired TCP and Wireless TCP, QoS Measurement of Wireless Networks. **Module 5:** Modelling **(8 Hours)** Mathematical Modelling of Network Functionalities - Combining them to derived overall performance. **Module 6:** Case Study: Implementation of opportunistic Networks in Challenged Network scenarios **(4 hours)** (a) Connection Mechanism (b) Sync - Transferring the information in Collaborative manner (c) Offline Dashboard (Information Summarization) (d)security
Text Books, and/or reference material	**Text Books:** 1. “Mobile Communication”, by Jochen Schiller (PEARSON EDUCATION LIMITED). 2. “Wireless Networking” A kumar, D. manjunath, J. Kuri, Elsevier, 2008. 3. “Wireless Communication”, T. S. Rappaport, Pearson, latest edition. **Research Papers:** 1. IEEE Infocom Tutorials slides by Prof. Nitin Vaidya. **Others:** Tools: ● Sniffer Tool (Wireshark) ● Simulation Tools: OMNET ONE NS3

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	2	1	1	1	1	1	-	2	-	2	2	2	3
CO#2	3	2	2	2	2	1	1	-	-	1	1	2	3	2	3
CO#3	3	2	3	3	3	2	2	1	-	3	3	2	3	3	3
CO#4	3	3	2	1	1	1	1	1	-	2	-	2	2	2	3
CO#5	3	2	2	2	2	1	1	-	-	1	1	2	3	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE514	Optical Communication	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA)):					
Electromagnetic Theory and Transmission Lines (ECC403), Communication Systems I (ECC401) and Communication Systems II (ECC501)		Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination					

Course Outcomes	**CO#1** Students will be able to understand circuits and system level implementation in lightwave technology. **CO#2** The students can design components and choose appropriate sources and receivers for an optical network. **CO#3** Understanding the usage of OTDR in monitoring an optical communication system.
Topics Covered/ Syllabus	Introduction to fiber optics, principles of optical fiber; Advantages. Elements of an optical fiber transmission link. **[4L]** Optical fiber characteristics, types of optical fibers; Attenuation and Dispersion in optical fiber: Signal attenuation and distortion in optical fibers, Dispersion effects in optical fibers.; OTDR **[10L]** Optical Sources: Structure and materials of LED and LD sources operating characteristics and modulation capabilities of the LED and LD sources. Source to Fiber Power launching and coupling, Lensing schemes for coupling improvement, Fiber to fiber couplings and alignment methods, Splicing techniques, Fiber Connectors. **[8L]** Optical Receiver: Optical receiver configuration and performance, Pre-amplifier design for optical receiver, analog and Digital receiver. Point to point transmission links, Wavelength division multiplexing, Optical data buses, Link power and rise time budget, Optical Amplifier. **[8L]** Optical Networking: Fiber optics in LAN, MAN, SAN, WAN, FDDI architecture, SONET/ SDH architecture, SONET/ SDH network elements **[8L]** Potential applications and future prospects of optical fibers, multimode intensity sensors and single mode, Interferometric sensors; Free space optical communication **[4L]**
Text Books, and/or Reference material	**Text Books:** 1. J. M. Senior, "Optical Fiber Communications", PHI, 2nd Ed. 2. G. Keiser, "Optical Fiber Communication", McGraw Hill, 3rd Ed. 3. Ghatak &Thyagarajan, "Introduction to fiber Optics", Cambridge University press. 4. Henry Zanger and Cynthia Zanger, *Fiber Optics Communication and Other Application*, Macmillan Publishing Company, Singapore 1991. **Reference Books:** 1. J.H.Franz & V.K.Jain, "Optical Communications", Narosa Publishing House. 2. Ghatak & Thyagarajan, "Contemporary Optics", Series Title: Optical Physics and Engineering, Springer 3. Amnon Yariv and Pochi Yeh, Photonics: Optical electronics for Modern Communication, 6th Ed., New York, Oxford University Press

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO / PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	1	2	1	2	2	1	1	1	1	1	1	2	1	1
CO#2	2	2	2	3	2	2	1	1	1	2	1	1	2	1	1
CO#3	3	3	3	1	1	2	1	1	2	2	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE515	Measurement and Instrumentation	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) and End Assessment (EA))					
None		CT+MT+EA					
Course Outcomes	CO#1: Understand characteristics of general measurement system CO#2: Apply qualitative analysis techniques in general measurement system CO#3: Apply quantitative analysis techniques in general measurement system CO#4: Understand basic building blocks of general measurement system CO#5: Design general measurement systems with functional blocks CO#6: Investigate complex designs in measurement systems with functional blocks						
Topics Covered	1. General measurement system, Static and dynamic characteristics of measurement systems [8L] 2. Loading effect, two port network model of measurement systems, signal noise [6L], 3. Reliability, Choice and Economics of Measurement Systems [3L] 4. Lagrangian dynamics [4L] 5. Sensing elements [6L] 6. Signal conditioning and Processing, Data presentation [6L] 7. Case studies in measurement system: [9L]						
Text Books, and/or reference material	**Text Books**: 1. Principles of Measurement Systems, John Bentley, 3rd Edition. **Reference Books**: 1. Mechatronics, A. Preumont. 2. Electronic Instrumentation and Measurements, David A. Bell, 3rd Edition.						

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO#3**
CO#1	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#2	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#3	2	3	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#4	1	1	3	2	1	1	1	1	1	1	1	1	2	3	1
CO#5	1	1	3	2	1	1	1	1	1	1	1	1	2	3	1
CO#6	1	1	2	3	1	1	1	1	1	1	1	1	2	3	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE516	Power Electronics	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT), End Assessment (EA))					
Basic Electrical and Electronics Engineering (XEC02), Signals and Systems (ECC303)		CT+MT+EA					
Course Outcomes	CO1: To learn the details of power semiconductor switches (Construction, Characteristics and operation) and working of various types of converters. CO2: To learn how to analyse the converters and design the components of them, under various load types. CO3: To learn about the control of various converters. Recognize the role power electronics play in the improvement of energy usage efficiency and the applications of power electronics in emerging areas.						
Topics Covered	**Module 1 (4 hrs): Introduction to Power Electronics Applications** Covers applications in motor control (traction and industrial process control), power supplies (personal computers, UPS), power transmission (FACTS, HVDC), chemical processes, battery charging, non-conventional energy sources, automotive electronics, and high-energy physics. Traces the evolution of power electronics from mercury arc rectifiers to SCRs and self-commutated switches, emphasizing their impact on the field. **Module 2 (4 hrs): Structure and Switches in Power Electronics** Explains structural differences between power electronics and low-power analog systems. Discusses various switching devices, with a focus on power diodes from an application perspective. Covers SCR device structure, static and dynamic characteristics, turn-on/turn-off constraints, and relevant ratings. **Module 3 (4 hrs): Diode Rectifiers and Applications** Focuses on the use of diode rectifiers in power supplies, motor drive front-end converters, battery chargers, and chemical processes. Includes single-phase half-wave rectifiers with R and R-L loads, single-phase full-bridge rectifiers with capacitive filters, and three-phase						

	full-bridge rectifiers. Harmonic issues are also addressed. **Module 4 (5 hrs): AC to DC Controlled Converters** Discusses applications in DC motor drives, battery charging, and HVDC systems. Covers single-phase fully controlled converters, including principles of line commutation, continuous and discontinuous conduction modes, R-L-E load analysis, inverter operation, and dual converter control. Also includes input displacement factor, distortion factor, harmonic effects, source inductance, and snubber requirements. The module also covers single-phase half-controlled converters with analysis of operating principles and input displacement factors. **Module 5 (2 hrs): Three-Phase Half-Wave AC to DC Converter** Describes the principle of operation, derivation of output voltage, and the issue of DC magnetization in input transformers. **Module 6 (3 hrs): Three-Phase Fully Controlled AC to DC Converter** Includes operational principles, derivation of average output voltage and displacement factor, inverter mode operation, commutation constraints, and the impact of source inductance. **Module 7 (4 hrs): Limitations and Advancements in AC to DC Conversion** Highlights the limitations of line-commutated converters and introduces single-phase unity power factor converters, switched-mode power conversion, and bidirectional power converters. **Module 8 (8 hrs): DC to DC Converters** Explains the limitations of linear power supplies and introduces switched-mode power supplies including Buck, Boost, Buck-Boost, Cuk, Flyback, and Forward converters. Also covers transfer functions for these converter topologies. **Module 9 (8 hrs): DC to AC Power Conversion (Inverters)** Covers the motivation for DC to AC conversion and the principles of inverter operation. Includes half-bridge, full-bridge, and three-phase six-step inverters, voltage control strategies, and PWM techniques.
Text Books, and/or reference material	**Text Books:** 1. M.H.Rashid, 'Power Electronics: Circuits, Devices and Applications', Pearson Education, PHI Third Edition, New Delhi, 2004. 2. P.S.Bimbra "Power Electronics" Khanna Publishers, third Edition, 2003. 3. L. Umanand, " Power Electronics Essentials and Applications", Wiley, 2010. **Reference Books:** 1. Joseph Vithayathil, 'Power Electronics, Principles and Applications', McGraw Hill Series, 6th Reprint, 2013. 2. Ashfaq Ahmed Power Electronics for Technology Pearson Education, Indian reprint, 2003. 3. Philip T. Krein, "Elements of Power Electronics" Oxford University Press, 2004 Edition. 4. Ned Mohan, Tore. M. Undel and, William. P. Robbins,' Power Electronics: Converters, Applications and Design', John Wiley and sons, third edition,2003. 5. Daniel.W.Hart, "Power Electronics", Indian Edition, Mc Graw Hill, 3rd Print.

COURSE ARTICULATION MATRIX

Mapping the Course Outcome (CO) to Programme Outcome (PO) and Programme Specific Outcome (PSO)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	2	2	1	1	1	-	1	1	2	3	3	1	2
CO#2	3	2	2	2	2	-	-	-	-	1	1	1	3	2	2
CO#3	3	2	2	3	2	-	-	-	-	-	-	1	3	2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE517	Active Filter Design	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT), End Assessment (EA))					
Microelectronic Circuits (ECC404), Signal and Systems (ECC303)		Class Assignments, Mid and End term examinations					

Course Outcomes

After the completion of the course, the student will be able to:

- CO1: Explain the operation of various High performance filters.
- CO2: Design Analog Circuits.
- CO3: Create the Layout of filters.
- CO4: Analyze the performance of different active filters.
- CO5: Interpret the use of Analog filter
- CO6: Compare the architectures based on Area/Power/Speed.

Topics Covered/ Syllabus

Module-I:

Introduction, Butterworth approximation, Chebyshev approximation, Inverse Chebyshev approximation, Synthesis of doubly terminated all-pole LC ladders filters, Synthesis of doubly terminated LC ladders with finite zeros of transmission. [L-5]

Module-II:

Network sensitivity - low sensitivity of doubly terminated ladders, Introduction to frequency transformations, Properties of the driving impedance of lossless LC networks, Tellegen's theorem and positive real functions, Low Pass-to-Low Pass, Low Pass-to-Band Pass, Low Pass-to-High Pass and Low Pass-to-Band Stop transformations, Richard's Transformation, RC-CR transformation, Emulation of an inductor with a capacitor and controlled sources, the gyrator, a second order transconductor capacitor filter. [L-8]

Module-III:

Cascade of biquads realization of high order low pass filters, equivalence of the parallel RLC and series RLC circuits. Dynamic Range in active filters - impedance scaling and its effect on dynamic range, Introduction to noise in electrical networks, node scaling, Dynamic range scaling in active filters.
[L-7]

Module-IV:

Biquad Ordering, Active Ladder Emulation / Leapfrog Filters, Effect of Transconductor non idelaities (parasitic capacitance/output resistance), parasitic poles, Effect of Finite Gain of the Transconductor. [L-5]

Module-V:

Single-ended Versus Differential Filters, Introducing the Differential-pair Based Fully Differential Transconductor, the Need for Common-mode Feedback, Stability of the Common-mode Feedback Loop, Common-mode Positive Feedback in Gyrators, Noise in the Differential Pair, Linearity of the Differential Pair,

	Cascoding, Noise in Cascodes, Layout Considerations and Multi-finger Transistors. Linearizing the Differential Pair, Resistive Degeneration. [L-7] **Module-VI:** Noise in Degenerated Transconductors, The Folded Cascode and Noise Analysis, Stabilizing filter bandwidth over process and temperature - the resistor servo loop, master-slave loops, Turning the filter into a VCO to estimate center frequency, example of a practical precision fixed-gm bias circuit, Introduction to accurate measurement and characterization techniques for active filters, Introduction to Active-RC filters, the use of an OTA instead of an opamp, swing and noise considerations, single stage OTAs, Multistage OTAs for use in CMOS Active-RC filters, The Miller compensated opamp in active-RC filters, noise considerations, noise in active-RC filters, Distortion and Intermodulation in filters, fixed gm-bias circuits [L-10]
Text Books, and/or Reference material	**Text Book**: 1. R Schaumann and M E Van Valkenburg, "Design of analog filters", First Edition, Oxford University Press, 2005.
	Reference Books: 1. G Daryanani, "Principles of active network synthesis and design", New York, Wiley, 1976. 2. M Van Valkenburg, "Analog filter design", New York, Holt Rinehart and Winston, 1982. 3. Franco S., "Design with operational amplifiers and analog integrated circuits", 3rd ed. New York, McGraw-Hill, 2002. 4. Allan Waters, "Active filter design", New York, McGraw-Hill, 1991. 5. Passive and Active Filters (Theory and Implementations) By: Wai-Kai Chen

COURSE ARTICULATION MATRIX

Mapping of Course Outcome (CO) to Programme Outcome (PO) and Programme Specific Outcome (PSO)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	1	3	3	1	1	1	1	1	1	1	2	2	2	1
CO#2	3	2	2	1	1	1	1	1	1	1	1	1	2	1	1
CO#3	3	3	3	1	1	1	1	1	1	1	1	1	3	3	2
CO#4	1	2	3	2	1	1	1	1	1	1	1	1	3	3	2
CO#5	2	3	1	2	1	2	2	1	1	1	1	1	2	3	2
CO#6	3	2	3	2	1	1	1	1	1	1	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE518	Nanoelectronics	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), Mid-Term (MT) and End Assessment (EA))
Microelectronic Circuits (ECC404), Semiconductor Devices and Technology (ECC302)	CT+MT+EA

Course Outcomes	• CO1: Understand state of the art in semiconductor device physics and materials technology to enable the Nano-Electronics. • CO2: Apply the fundamentals of classical CMOS technology. • CO3: Implement the scaling of MOSFET in the sub-100nm regime. • CO4: Apprehend the need of non-classical transistors with new device structure and Nano-materials.
Topics Covered	**Module I: (L – 4)** Introduction to nanotechnology, the size of things, history of nanotechnology, fabrication method (top-down and bottoms-up), emerging applications of nanotechnology **Module II: (L – 8)** Electronic and Optical properties of nanostructures. Energy sub-bands. Electron transport in two –dimensional electron gas (density of states), Carrier scattering, resistance of a ballistic conductor, Transmission probability calculation, Electron tunneling, Resonant tunneling, Coupled nanoscale structures and Super lattices. **Module III: (L – 10)** Shrink-down approaches: Electronic devices Based on Nanostructures: Advance Heterostructure Devices, Downscaling of the MOSFET. Nanoscale FET Transistors, the Ballistic FET, Resonant Tunneling Devices and Circuits, Single Electron Transistor and Related Devices. Devices based on carbon nanotubes, Spintronic Devices. **Module IV: (L – 10)** Optoelectronic Devices using Nanostructures: Quantum well and Quantum Dot LASERS, Quantum Cascade LASER, Quantum well infrared photo detector, Super lattice LASER. **Module V: (L – 10)** Nanotechnology: Deposition techniques for Nanoscale Devices, Nanolithography, Self-Assembly Techniques, Nanomaterials, Nanoparticles, Nanowires, Nanomagnetic Materials, Nanostructure Surfaces; Instrumentation for nanoscale electronics: The Atomic Force Microscope (AFM), Scanning Tunneling Microscope and scanning near field optical microscope.
Text Books, and/or reference material	1. Introduction to Nanotechnology, C.P. Poole Jr., F.J. Owens,Wiley (2003). 2. Nanoelectronics and Information Technology (Advanced Electronic Materials and 3. Novel Devices), Waser Ranier,Wiley-VCH (2003). 4. Nanosystems, K.E. Drexler, Wiley (1992) 5. The Physics of Low-Dimensional Semiconductors, John H. Davies, Cambridge 6. University Press, 1998. 7. Fundamentals of Modern VLSI Devices, Y. Taur and T. Ning, Cambridge University Press. 8. "Nanoelectronics and Nanosystems," Karl Goser, Springer, 2004

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	1	2	1	3	3	3	1	2	2	1	2	3	3	2
CO#2	3	3	1	2	3	1	3	1	3	2	1	2	3	2	3
CO#3	3	3	1	3	3	2	2	1	3	2	1	2	3	2	2
CO#4	3	3	2	3	3	2	2	1	3	2	1	2	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE519	Mechatronics Systems	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), Mid-Term (MT), End Assessment (EA))
NIL	CT+MT+EA

Course Outcomes	• CO1: **Understand** characteristics of mechatronics system • CO2: **Apply qualitative analysis** techniques in mechatronics system • CO3: **Apply quantitative analysis** techniques in mechatronics system • CO4: **Understand** basic building blocks of general mechatronics system • CO5: **Design** general mechatronics system with functional blocks • CO6: **Investigate complex designs** in mechatronics system and case studies
Topics Covered	Introduction to mechatronics [1L] Sensors and Transducers, Pneumatic and Hydraulic, Mechanical Actuation Systems, Electrical actuation systems [8L] Signal Conditioning circuits [4L] Digital Processing Elements [3L] Data Presentation Systems [2L] System models and Dynamic response [3L] System Transfer functions and frequency response [3L] Closed loop controllers [2L] Artificial Intelligence [2L] Microcontrollers and programming [4L] Interfacing and communication [2L] Case studies [8L]
Text Books, and/or reference material	**Text Book**: 1. Mechatronics, by W. Bolton, Fourth Edition, Pearson

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#2	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#3	2	3	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#4	1	1	3	2	1	1	1	1	1	1	1	1	2	3	1
CO#5	1	1	3	2	1	1	1	1	1	1	1	1	2	3	1
CO#6	1	1	2	3	1	1	1	1	1	1	1	1	1	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE520	Digital IC Design	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous (CT), Mid-semester assessment (MA) and end assessment (EA)):					
Digital Circuits and Systems (ECC304)		Assignments, Mid-semester Examination and End Semester Examination					
Course Outcomes	At the end of the course, a student will be able to: CO#1: Understand the characteristics of CMOS inverter and interconnects. CO#2: Study the Static and dynamic characteristics of MOS inverter CO#3: Learn the basic steps of ASIC and fabrication process. CO#4: Analyze the performance of CMOS inverter circuits. CO#5: Illustrate the combinational and sequential logic circuits CO#6: Understand the recent trends in VLSI Design & its research issues in industry/ academia						
Topics Covered	**Module-I:** (L – 3) **Overview of VLSI Design:** Historical perspective, overview of VLSI design methodologies, VLSI design flow, design hierarchy, concepts of regularity, modularity, and locality, VLSI design styles, design quality, packaging technology, CAD technology, ASIC Design flow. **Module-II:** (L – 6) **Fabrication of MOSFETs:** Fabrication process flow- basic steps, the CMOS n-Well process, layout design rules, stick diagram, full-custom mask layout design. **Module-III:** (L – 6) **MOS Transistor:** The metal oxide semiconductor (MOS) structure, MOS system under external bias, structure and operation of MOS transistor (MOSFET), MOSFET current-voltage characteristics, MOSFET scaling and small-geometry effects, MOSFET capacitances.						

	Module-IV: (L – 4) **Modelling of MOS Transistors:** Basic concepts, state-of-art MOSFET models, capacitance models, comparison of SPICE MOSFET models. **Module-V:** (L – 4) **MOS Inverter (Static Characteristics):** Resistive-load inverter, inverter with n-type MOSFET load, CMOS inverter. **Module-VI:** (L – 4) **MOS Inverters (Switching Characteristics and Interconnects effects):** Delay-time definitions, calculation of delay times, logical efforts, inverter design with delay constraints, estimation of interconnect parasitics, calculation of interconnect delay, Bus vs. Network-on-Chip (NoC), switching power dissipation of CMOS inverters. **Module-VII:** (L – 5) **Combination CMOS Logic Circuits:** MOS logic circuits with depletion nMOS loads, CMOS logic circuits, complex logic circuits. CMOS transmission gates (pass gates). **Module-VIII:** (L – 5) **Sequential MOS logic circuits:** Behavior of bistable elements, SR latch circuits, clocked latch and flip-flop circuits, CMOS D-latch and edge-triggered flip-flop. **Module-IX:** (L – 5) **Dynamic logic Circuits:** basic principle of pass transistor circuits, voltage bootstrapping, synchronous dynamic circuit techniques, dynamic CMOS circuit techniques, high-performance dynamic CMOS circuits.
Text Books, and/or reference material	**Text Book**: 1. CMOS Digital Integrated Circuits, Sung-Mo Kang,Yusuf Leblebici, 3rd edition, Tata McGraw-Hill, 2003 **Reference Books**: 1. J. Rabaey, A. Chandrakasan and B. Nikolic, Digital Integrated Circuits: A Design Perspective, 2nd Edition, Prentice Hall 2004. 2. N. H. E. Weste and C. Harris, “Principles of CMOS VLSI Design: A System Perspective, 3rd Edition, Pearson Education 2007.

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE521	Statistical Signal Processing	PEL	3	0	0	3	3
Pre-requisites		Continuous Assessments : Class Assessment (CA), Mid-Sem (MA) and End-Sem Assessment (EA)					
Digital Signal Processing (ECC402), Probability Theory for Engineering Applications		(CA-15) +(MA-25) + (EA-60)					

Course Outcomes

CO1: Students are able to apply hypothesis testing to signal and detection problems.
CO2: Students are able to evaluate detector performance.
CO3: Students can decide and choose among MLE, MAP and MMSE estimators given a parameter estimation task.
CO4: Students are able to apply and design least squares based adaptive filters for stochastic signals.

Topics Covered

Module 1: Introduction to Random Processes (6 hrs)

Covers review of probability and random variables, linear algebra of random variables, random processes, linear shift-invariant systems with random inputs, white noise, and the spectral factorization theorem.

Module 2: Estimation Theory (8 hrs)

Introduces linear models of random signals, basic estimation theory, minimum variance unbiased estimation (MVUE), Cramér-Rao lower bound (CRLB), advanced CRLB analysis, and MVUE using sufficient statistics.

Module 3: Methods of Parameter Estimation (4 hrs)

Focuses on the method of moments and maximum likelihood estimation (MLE), properties of MLE, and Bayesian estimation techniques.

Module 4: Wiener Filter (5 hrs)

Explores optimal linear filtering using the Wiener filter, including FIR Wiener filter, noncausal IIR Wiener filter, and causal IIR Wiener filter.

Module 5: Linear Prediction of Signals (4 hrs)

Discusses concepts and implementation of linear prediction across three progressive stages.

Module 6: Adaptive Filters (4 hrs)

Introduces adaptive filtering concepts, algorithmic development, and practical implementations across four subtopics.

Module 7: Recursive Least Squares (RLS) Adaptive Filter (4 hrs)

Explains the RLS adaptive filtering algorithm and its detailed working in two parts.

Module 8: Kalman Filter (4 hrs)

Covers the basics of the Kalman filter and introduces the vector Kalman filter for multidimensional systems.

	Module 9: Introduction to Applications of SSP (2 hrs) Provides an overview of SSP applications in areas such as communications, medical diagnosis, radar and climate modeling, pattern recognition, speech/audio processing, image/video processing, and geophysical signal processing.
Text Books, and/or Reference Materials	**Text Books**: 1. M. H. Hayes, "Statistical Digital Signal Processing and Modeling " , 2002, John Willey 2. S. M. Kay "Fundamentals of Statistical Signal Processing : Estimation Theory", 1993, Prentice Hall 3. D. G. Manolakis, V. K. Ingle, and S. M. Kogon, "Statistical and Adaptive Signal Processing" 2000, McGraw Hill

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	1	2	1	3	3	3	1	2	2	1	2	3	3	2
CO#2	3	3	1	2	3	1	3	1	3	2	1	2	3	2	3
CO#3	3	3	1	3	3	2	2	1	3	2	1	2	3	2	2
CO#4	3	3	2	3	3	2	2	1	3	2	1	2	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 40				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE522	Biomedical Signal Processing	PEL	3	0	0	3	3
Pre-requisites		ECC303 - Signals and Systems ECC402 - Digital Signal Processing					
Course Outcomes	After the completion of the course, the student will be able to **CO 1**: Understand the origin and characteristics of major biomedical signals. **CO 2**: Apply signal processing techniques to filter and preprocess biomedical signals. **CO 3**: Interpret relevant features from bio-signals in time-frequency domains. **CO 4**: Design and implement classification models for biomedical signal data. **CO 5:** Analyze and interpret results in real-life applications like prosthetics and BCI.						
Topics Covered	**Module I: Introduction to Biomedical Signals [L-6]** Origin and characteristics of bio-signals, Classification: ECG, EEG, EMG, PCG, etc., Signal acquisition systems and electrodes, Basics of signal conditioning and instrumentation, Suggested Lab: Introduction to signal acquisition (ECG/EEG kits or PhysioNet data) **Module II: Preprocessing and Filtering Techniques [L-10]** Noise and artifacts in biomedical signals, Time and frequency domain analysis, FIR and IIR filter design, Baseline wander removal, motion artifact filtering, Suggested Lab: ECG/EMG						

	filtering and visualization using Python/MATLAB **Module III: Feature Extraction and Transformation [L-10]** Time-domain features (RMS, zero crossing, etc.), Frequency-domain analysis: FFT, PSD, Time-frequency analysis: STFT, Wavelet Transform, Principal Component Analysis (PCA), Suggested Lab: Feature extraction from EMG or EEG datasets **Module IV: Detection, Classification and Machine Learning [L-4]** Peak detection, QRS complex detection, Pattern classification: LDA, SVM, KNN, Basics of DNNs for signal classification, Feature selection and dimensionality reduction, Suggested Lab: EMG gesture classification / EEG mental state classification using ML **Module V: Biomedical Applications and Case Studies [L-10]** EMG for prosthetics, EEG for mental health and BCI, ECG for arrhythmia detection, Multimodal signal fusion, Emerging areas: TinyML in BSP, Federated BSP, Suggested Lab: End-to-end mini project using EMG or EEG dataset
Text Books, and/or reference material	**Text Books:** **1.** "Biomedical Signal Processing and Signal Modeling" by Niedermeyer, E., & da Silva, F. L. **2. "Biomedical Signal Processing: Principles and Techniques" by D. C. Reddy** **Reference Material:** 1. "Signals and Systems in Biomedical Engineering: Signal Processing and Physiological Systems Modeling" by J. D. Enderle, R. C. Nesbitt, and J. E. Bronzino **2.** "Biomedical Engineering Handbook, 2nd Edition" by Joseph D. Bronzino

COURSE ARTICULATION MATRIX

Mapping CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 43				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE523	Internet of Things (IoT) Technology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: Continuous (CT), Mid-Term (MT), End Assessment (EA)					
NIL		CT+MT+EA					

Course Outcomes	**CO1**: Explain the term IoT and understand the main components of IoT systems. **CO2**: Recognize, interpret and apply a variety of enabling technologies, connectivity technologies and communication protocols that occur in IoT systems. **CO3**: Design and analysis of a complete working IoT system involving prototyping, programming and data analytics
Topics Covered	**Module 1: Introduction to IoT (5L)** Introduction and definition of IoT. Basics of networking: network types, network topologies, OSI model, addressing, TCP/IP. Predecessors of IoT: Wireless Sensor Networks (WSN), Machine-to-Machine (M2M) communication, and Cyber-Physical Systems. **Module 2: IoT Enabling Technologies (8L)** Cloud computing, big data analytics, and embedded systems. IoT levels (Level 1 to Level 6). Introduction to sensors, actuators, microcontrollers, and their interfacing. Sensor characteristics and types. Sensor interfacing examples: gas sensors, pH sensors, pulse sensors with NodeMCU/Arduino. Actuators: types and functions. Overview of microcontrollers. **Module 3: IoT Communication Technologies (6L)** Constrained nodes and networks: types, lossy and low-power networks. Messaging protocols: MQTT, CoAP, XMPP, DDS. Addressing and identification protocols: IPv4, IPv6, Uniform Resource Identifier (URI), 6LoWPAN. Discovery protocols: Universal Plug and Play, Multicast DNS. **Module 4: IoT Connectivity Technologies (2L)** IEEE 802.15.4, Zigbee, RFID, NFC, Sigfox, LoRa, NB-IoT, Wi-Fi, and Bluetooth. **Module 5: Cloud for IoT (2L)** Challenges in cloud integration. Selection of cloud service providers. Introduction to fog computing: working principles, edge and fog computing, and security aspects. **Module 6: Data Analytics (5L)** Data analysis and machine learning: supervised and unsupervised learning. Types of models: classification, regression, clustering. Model building process, algorithm selection, performance evaluation. Overview of big data platforms. **Module 7: IoT Case Studies and Future Trends (6L)** Applications of IoT in agriculture, vehicles, and healthcare. Emerging paradigms: IoBT (Internet of Battlefield Things), IoV (Internet of Vehicles), IoNT (Internet of Nano Things), IoD (Internet of Drones), IoSpace, NFV (Network Function Virtualization), SDN (Software Defined Networking), and 5G as an IoT enabler. **Module 8: IoT Hands-On (9L)** Home automation: smart lighting. Environmental monitoring: air pollution monitoring. Healthcare: elderly fall detection. Smart transportation: drowsiness prevention using IoT-based driver assistance systems.
Text Books, and/or reference material	**Text Books**: 1. Shriram K Vasudevan; Abhishek S Nagarajan; RMD Sundaram, *Internet of Things*, 2nd Edition, Wiley, New Delhi, 2020. 2. S. Mishra, A. Mukherjee, A. Roy, *Introduction to IoT*, 1st Ed., Cambridge University, UK, 2021. **Reference Books**:

3. A. Bahga, V. Madisetti, *Internet of Things: A Hands-on approach*, 1st Ed., Universities Press (India) Pvt. Ltd., Hyderabad, 2014.
4. K. N. Raja Rao (editor), *Internet of Things: Concepts and Applications*, 1st ed., Wiley India, 2021.

COURSE ARTICULATION MATRIX

Mapping of Course Outcome (CO) to Programme Outcome (PO) and Programme Specific Outcome (PSO)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	2	1	1	1	1	1	-	2	-	2	2	2	3
CO#2	3	2	2	2	2	1	1	-	-	1	1	2	3	2	3
CO#3	3	2	3	3	3	2	2	1	-	3	3	2	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE524	Audio Signal Processing	PEL	3	0	0	3	3
Pre-requisites		ECC402 - Digital Signal Processing ECC303 - Signals and Systems					
Course Outcomes	After the completion of the course, the student will be able to **CO 1**: Explain and apply the fundamental concepts of audio signal processing **CO 2**: Time-frequency analysis of audio signals. **CO 3**: Proficiency in Audio Software and Tools **CO 4**: Ability to solve problems related to noise reduction, echo cancellation, etc. **CO 5**: Design and implement an audio processing project such as Speech Recognition						
Topics Covered	**Module I: Introduction to Audio Signal Processing [L-3]** Fundamental concepts and basic characteristics of audio signal, sound capturing process, characteristics of microphones, sampling, quantization **Module II: Time-Frequency Analysis for Audio Signal Processing [L-7]** Linear Time-Invariant Discrete-Time Systems, Discrete-Time Fourier Transform and its properties for real signals, Short-Time Fourier Transform (STFT), Short-Time Synthesis of Speech, Overlap-and-Add Method for Short-Time Synthesis, Spectrographic Analysis of Speech Signals, Wavelet transform, Homomorphic signal processing **Module III: Audio Feature Extraction and Representation [L-6]** Type of audio features; Time-domain audio features, RMS energy and zero-crossing rate, Cepstral analysis, Mel Spectrogram, MFCC, Frequency-Domain Audio Features: Spectral centroid and bandwidth, Band-Energy Ratio **Module IV: Speech Signal Processing [L-6]** Speech Signal Characteristics, Basic concepts: speech production and perception, Waveform coding: PCM, ADPCM, Vocoders: channel, formant, LPC vocoders Code-excited linear prediction (CELP) **Module V: Fundamentals of Machine Learning and Deep Learning Basics [L-6]** Introduction to neural networks, Activation functions, loss functions, and optimization Basics of deep learning architectures: CNN, RNN (LSTM and GRU), Transformer, Data preprocessing and augmentation, Training, validation, and testing splits, Overfitting, regularization, and dropout, CNNs for audio classification Spectrogram-based CNN models Applications in music genre classification and sound event detection						

	Module VII: Music Information Retrieval [L-4] Music signal characteristics, Tempo and beat tracking, Chord recognition and music transcription **Module VI: Audio/Speech Processing Applications [L-8]** **Section A: Speech and Speaker Recognition** Basics of automatic speech recognition (ASR), Hidden Markov models (HMMs) and Gaussian mixture models (GMMs), Deep learning approaches for ASR, Speaker identification and verification, Keyword Spotting System **Section B: Speech Synthesis and Speech Enhancement** Text-to-speech (TTS) systems, Concatenative and parametric synthesis, Evaluation of synthetic speech, Noise reduction techniques, Echo cancellation, Speech enhancement algorithms
Text Books, and/or reference material	**Text Books:** 1. "Introduction to Digital Speech Processing" by Lawrence R. Rabiner and Ronald W. Schafer, 2007. *Foundations and Trends® in Signal Processing*, 1(1–2), pp.1-194. 2. "Discrete-Time Speech Signal Processing: Principles and Practice" by Thomas F. Quatieri, 2002. *Pearson Education India*. **Reference Material:** 1. "Speech and Audio Signal Processing: Processing and Perception of Speech and Music" by Ben Gold, Nelson Morgan, and Dan Ellis, 2011. *John Wiley & Sons*. 2. "Audio Signal Processing and Coding" by Andreas Spanias, Ted Painter, and Venkatraman Atti, 2006. *John Wiley & Sons*. 3. "Springer Handbook of Speech Processing" (Vol. 1) edited by Jacob Benesty, M. Mohan Sondhi, and Yiteng Huang, 2008. *Berlin: Springer*.

COURSE ARTICULATION MATRIX

Mapping CO (Course Outcome)
to
PO (Programme Outcome) and PSO (Programme Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SIXTH SEMESTER

<table>
<tr><th colspan="8">Department of Humanities and Social Sciences</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>HSC631</td><td>ECONOMICS AND ACCOUNTANCY</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● CO1: To review basic economic principles with students;
● CO2: To introduce students basic capital appraisal methods used for carrying out economic analysis of different alternatives of engineering projects or works;
● CO3: To educate the students on how to evaluate systematically the various cost elements of a typical manufactured product, an engineering project or service, with a view to determining the price offer.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I
PART 1: Economics
Group A: Microeconomics Economics:
Basic Concepts
Theory of Production, Cost and Firms, Analyses of Market Structures: Perfect Competition, Monopoly Market, General Equilibrium & Welfare Economics[14 hrs.]
Module II
Group B: Macroeconomics
Introduction to Macroeconomic Theory, National Income Accounting, Determination of Equilibrium Level of Income, Money, Interest and Income, Inflation and Unemployment, Output, Price and Employment. [14 hrs.]
Module III
PART 2: Accountancy
Introduction to Accounting, Financial Statement Preparation and Analysis. Financial Ratio Analysis. [14 hrs.]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Suggested Text Books
1. Koutsoyiannis: Modern Microeconomics
2. Maddala and Miller: Microeconomics
3. Gupta, R. L. and Radhaswamy, M: Financial Accounting; S. Chand & Sons
4. Ashoke Banerjee: Financial Accounting; Excel Books
5. W. H. Branson: Macroeconomics – Theory and Policy (2nd ed)
6. N. G. Mankiw: Macroeconomics, Worth Publishers
Suggested Reference book
1. Dornbush and Fisher: Macroeconomic Theory
2. SoumyenSikder: Principles of Macroeconomics
3. AnindyaSen: Microeconomics: Theory and Applications
4. Pindyck & Rubenfeld: Microeconomics
5. Maheshwari: Introduction to Accounting; Vikas Publishing</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	2	3	2	3	2	3	3	3
CO2	3	3	3	3	3	3	2	2	3	3	3	3
CO3	3	3	3	3	3	3	2	2	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) **2: Moderate (Medium)** **3: Substantial (High)**

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	**Total number of contact hours : 42**				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC601	VLSI Design	PCR	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Digital Circuits and Systems [ECC304], Microelectronics [ECC404], Computer Organization and Architecture [ECC502]	Continuous Assessment (CA): Quizzes/Class tests/Assignments/Attendance
Course Outcomes	After successful completion of the course, the student will be able to: • **CO 1:** Acquire ideas about the digital IC design techniques. • **CO 2:** Understand the characteristics of a CMOS inverter. • **CO 3:** Identify the basic steps of ASIC Design Flow and fabrication process. • **CO 4:** Analyze the static and dynamic characteristics of CMOS circuits. • **CO 5:** Design and implementation of combinational and sequential circuits. • **CO 6:** Evaluate the performance of CMOS circuits.
Topics Covered	**Module I. Overview of VLSI Design [L – 2]** Overview of VLSI design methodologies, design hierarchy, concepts of regularity, modularity, and locality, VLSI design styles, design quality, packaging technology, Recent Trends in VLSI Design & its research issues in industry, MOS Transistor. **Module II. MOS Inverter- Static & Switching Characteristics [L – 8]** CMOS inverter, Delay-time definitions, calculation of delay times, logical efforts, inverter design with delay constraints, estimation of interconnect parasitics, calculation of interconnect delay, Bus vs. Network-on-Chip (NoC), switching power dissipation of CMOS inverters. **Module III. Combinational and Sequential CMOS Logic Circuits [L – 8]** MOS logic circuits with depletion nMOS loads, CMOS logic circuits, complex logic circuits, CMOS transmission gates (pass gates), ratioed, dynamic, and pass transistor logic circuits, and domino circuits. Behavior of bi-stable elements, SR latch circuits, clocked latch and flip-flop circuits, CMOS D-latch, and edge-triggered flip-flop. **Module IV. RTL-to GDS II [L – 20]** Basics of IC; an overview of VLSI design flow, and layout design rules, stick diagram; idea to RTL; functional verification: simulation and formal verification; pre-synthesis: linting, CDC, RDC, and X-propagation; Synthesis: technology mapping, logic optimization, post-synthesis: LEC, GLS; static timing analysis; constraints, timing path, setup time and hold time static, slack, clock skew and jitter, clock, reset and power

	distributions; testing: insertion, ATPG, BIST; chip planning and physical verification; physical design; partitioning, floor planning, power planning, placement, CTS, routing, post route LEC, post routing GLS, DFM, ECO, DRC, physical and timing sign-off, sealring, dummy filling, SPICE simulation, DRC and antenna clean, GDS II extraction. **Module V. Semiconductor Memories [L – 4]** Memory hierarchy and types, SRAM, DRAM structure, and implementations.
Text Books, and/or Reference Material	**Text Books:** 1. N. H. E. Weste and C. Harris, "*Principles of CMOS VLSI Design: A System Perspective"*, 3rd Edition, Pearson Education 2007. 2. Sung-Mo Kang, Yusuf Leblebici, Chulwoo Kim, "*CMOS Digital Integrated Circuits*", 4th edition, McGraw-Hill, 2018. 3. Luciano Lavagno, Igor L. Markov, Grant E. Martin, Louis K. Scheffer, "Electronic Design Automation for Integrated Circuits", Handbook, Second Edition, - 2016, - CRC Press. 4. Michael Smith, Addison-Wesley, "Application-Specific Integrated Circuits," Professional; 1 edition, June 20, 1 **Reference Books:** 1. Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic, "Digital Integrated Circuits: A Design Perspective," 2nd Edition, Pearson Education, 2009. 2. J. Bhaskar, "Verilog HDL synthesis: a practical primer," August 1998. 3. Giovanni De Micheli, "Synthesis and Optimization of Digital Circuits," McGraw-Hill, 1994. 4. J. Bhasker, Rakes Chadha, "Static Timing Analysis For Nanometer Designs: A Practical Approach," Springer, 2009. 5. J. D. Plummer, M. Deal, and P. B. Griffin, "Silicon VLSI Technology: Fundamentals, Practice, and Modeling," Pearson, Springer; 2009.

COURSE ARTICULATION MATRIX

Mapping of CO (Course outcome) and PO (Programme Outcome)

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

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECC602</td><td>Microwave and Antenna Engineering</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods
(Continuous (CT), Mid-Term (MT), End Assessment (EA))</td></tr>
<tr><td colspan="3">Electromagnetic Theory and Transmission lines (ECC403)</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To enable the student to understand the basic principles in microwave and antenna system design
• CO2 To enhance the understanding in the domain of microwave components for next generation communication systems.
• CO 3 To enhance the knowledge in antenna as well as antenna array designs.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I: Microwave Frequency Bands and Components
Microwave frequency bands, regulation, and design synthesis of microwave passive components. Concept of S-parameters. Design and analysis of directional coupler, power divider, magic tee, attenuator, and resonator. Principles of microwave semiconductor devices: Gunn diodes, IMPATT diodes, Schottky barrier diodes, and PIN diodes. Overview of microwave tubes: klystron, traveling wave tube (TWT), and magnetron.
Module II: Microwave Circuit Design
Impedance transformation and matching using Smith chart. Design of microwave filters, RF and microwave amplifiers, power amplifiers, low-noise amplifiers, mixers, and oscillators.
Module III: Antenna Basics and Parameters
Physical concept of radiation, near- and far-field regions, and radiated field and power. Antenna parameters: radiation pattern, HPBW, FNBW, beam area and efficiency, polarization, radiation intensity, directivity, gain, efficiency, radiation resistance, resolution. Antenna aperture: physical and effective, aperture efficiency, effective height. Transmission formula, impedance matching, baluns, antenna noise temperature, G/T ratio. Friis transmission equation, link budget and margin, and noise characterization of microwave receivers.
Module IV: Antenna Arrays
Two-element array, array factor, pattern multiplication, and uniformly spaced arrays with both uniform and non-uniform excitation. Introduction to smart antennas.
Module V: Radiation Mechanisms and Antenna Types
Radiation mechanisms of linear wire and loop antennas, aperture antennas, reflector antennas, planar antennas, and frequency-independent antennas. Design considerations and applications.
Module VI: Electromagnetic Wave Propagation
Modes of wave propagation and atmospheric structure. Ground wave propagation: plane earth reflections, space and surface waves, wave tilt, curved earth reflections. Space wave propagation: distance and height variations, earth curvature effects, absorption, super refraction, M-curves, duct propagation, and tropospheric scattering. Sky wave propagation: ionospheric structure, refraction and reflection, ray path, critical frequency, MUF, virtual height, skip distance, and multi-hop propagation.</td></tr>
<tr><td>Text Books, and/or reference</td><td colspan="7">Text Books:
T1. D M Pozar, “Microwave Engineering”, Fifth Edition, Wiley India, New Delhi, India, 2005.</td></tr>
</table>

material	T2. Liao, Samuel Y., "Microwave devices and circuits 3/E", Pearson Education India, 1989. T3. Collin, Robert E., "Foundations for microwave engineering 2/E", John Wiley & Sons, 2007. T4. John D Krauss, Ronald J Marhefka and Ahmad S. Khan, "Antennas and Wave Propagation: Fourth Edition, Tata McGraw-Hill, 2006. **Reference Books**: R1. Radmanesh, Matthew M., "Radio frequency and microwave electronics illustrated", New Jersey: Prentice Hall, 2001. R2. CA Balanis, Advanced Electromagnetic Engineering, John Wiley, New York, 2003. R3. Cheng, David Keun, "Field and wave electromagnetics", Pearson Education India, 1989.

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	1	1	1	1	1	1	-	-	-	1	3	1	2
CO#2	3	2	2	2	2	-	-	-	-	-	-	1	3	2	2
CO#3	3	2	2	2	2	1	-	1	-	-	-	1	2	2	3
CO#4	3	2	1	1	1	1	1	1	-	-	-	1	3	2	3

COURSE ARTICULATION MATRIX

Correlation levels 1, 2 or 3 as defined above:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS651	VLSI Design Lab	PCR	0	0	3	3	2
Pre-requisites: Knowledge of Basic Electronics, Semiconductor Devices, and Digital Electronics		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Course Objectives	This lab introduces CMOS schematic design, layout techniques, automated design tools, netlist synthesis, place & route and timing verification. EDA Tools will be introduced in this Lab.						
Course Outcomes	**CO#1:** Demonstrate understanding of fundamental of VLSI Designs **CO#2:** Familiarity with EDA tools for VLSI design. **CO#3:** Learn basics and analysis of functional verification of logic Gates. **CO#4:** Design and implementation of Combinations Circuits **CO#5:** Design and implementation of Sequential Circuits **CO#6:** Demonstrate implementation of FPGA with digital circuits.						

Topics Covered/ Syllabus	List of experiments: 1. Introduction to Verilog HDL 2. Design and functional verification of basic logic gates using Verilog HDL 3. Combinational logic circuit design using Verilog HDL 4. Sequential logic circuit design using Verilog HDL 5. Configuring FPGA with combinational circuit 6. Configuring FPGA with sequential circuit
Reference Materials	1. M. Morris Mano, Michael D Ciletti, "**Digital Design**", Pearson, 2008. 2. M. Morris Mano, Michael D Ciletti, "**Digital Design: With an Introduction to Verilog HDL**" Pearson Education, 2013. 3. Samir Palnitkar, "**Verilog HDL**," Second Edition, Pearson education 2003. 4. J. Bhaskar, "**Verilog HDL Synthesis: A Practical Primer**", Star Glaxy Publishing, 1998.

COURSE ARTICULATION MATRIX

Mapping of CO (Course outcome) and PO (Programme Outcome)

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

Correlation levels 1, 2 or 3 as defined above:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS652	Microwave and mm-Wave Lab	PCR	0	0	3	3	2
Pre-requisites: Electromagnetic Theory and Transmission Lines (ECC403)		Course Assessment methods : Day to day evaluation during the laboratory session and End Semester Examination					
Course Outcomes	After successful completion of this course, the students will be able to • CO#1: Understand the characteristics of Microwave sources and passive components, and use microwave test bench to measure operating signal frequency, wavelength and VSWR. • CO#2: Analyze the characteristics of microwave sources and the radiation characteristics of different antennas in terms of their radiation parameters. • CO#3 Use VNA to study the characteristics of microwave passive components and antenna. • CO#4: Identify and design a suitable antenna for different communication systems as per the requirements of given specifications.						
Topics Covered/ Syllabus	1. Study of the characteristics of Gunn Diode and Gunn Oscillator 2. Study of the characteristics of magic-Tee and directional coupler 3. Measurement of source frequency, guided wavelength and VSWR using microwave test bench						

	4. Measurement of input impedance with unknown load. 5. Use of Microwave Power meter 6. Study of reflex-klystron characteristics A. Measurement of output power using power meter B. Plot of beam voltage vs repeller voltage. C. Plot of frequency vs. Repeller voltage. D. Plot of frequency vs. Output power. 7. To study the radiation characteristics of various antennas - wire antenna and planar antennas such as dipole, monopole, folded dipole, Yagi-Uda log periodic, loop, microstrip patch. 8. Measurement of return loss of a given antenna using Network Analyzer 9. Study of radiation pattern of Horn antenna and understand the Friis transmission equation 10. To design and study the characteristics of microstrip antenna using EM simulation software.
Reference Materials	Text Books: 1. Sisodia and Raghuvangshi, Microwave Laboratory Manual, New Age International. 2. Lab. Instruction manual. Reference Books: 1. Balanis, Antenna Theory and Design, Wiley Publications 2. John D. Krauss, Antennas for all Applications, TMH. 3. Edward C.Jordan and Keith G.Balmain" Electromagnetic Waves and Radiating Systems" Prentice Hall of India.

COURSE ARTICULATION MATRIX

Mapping CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SIXTH SEMESTER DEPTH ELECTIVES

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 43				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE610	Detection and Estimation Theory	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) and End Assessment (EA))					
Probability Theory for Engineering Applications		CT+MT+EA					
Course Outcomes	• CO1: To familiarize students with Classical Statistical Inference Techniques and their applications to Communication and Signal processing						

	• CO2: To familiarize students with Signal Detection Theory • CO3: To develop required mathematical skills for design and implementation of statistical signal processing algorithm
Topics Covered	**Topic 1: Random Signal and Random Process Basics [5]** Important probability distribution functions: Gaussian, Chi-square, Rayleigh, Rician, Student's t, F, Cauchy etc. Bivariate and Multivariate Distribution Random Process, Correlation properties, Stationarity, Ergodicity, Gaussian Process, Power Spectral Density **Topic 2: Classical Decision Theory [10]** Introduction to signal detection problems, Bayes Criterion: Binary Hypothesis testing, M-ary hypothesis testing, Maximum Likelihood based Optimal detection, LRT (Likelihood Ratio Test) and performance. Neyman Pearson Criterion for optimal detection , Minimum probability of error detector, Minimax Criterion **Topic 3:Detection of Deterministic and random Signal [8]** Matched Filter Detection, Optimal detection for white and Nonwhite noise, Multiple Hypothesis testing, Estimator Correlator, Energy Detector **Topic 5: Detection of Signal with unknown parameters [6]** Composite Hypothesis Testing : Bayesian Approach and GLRT, Sinusoidal detection **Topic 6**: **Estimation Techniques [8]** Introduction to signal Estimation, Unbiased estimators, Minimum variance unbiased estimator (MVUE), MVUE Criterion, Cramer Rao Lower bound(CRLB), Best Linear Unbiased Estimator(BLUE), General CRLB for signals in white noise, Least Square Estimation and Recursive Least Square Estimation. **Topic 7: Random parameter Estimation**: [**6**] Bayesian Formulation, Minimum mean square error (MMSE) and MAP estimation, Linear MMSE estimation, Wiener and optimum MMSE Filtering
Text Books, and/or reference material	**Text Books:** 1. Fundamentals of Statistical Signal Processing, (Vol 1 & Vol 2) S.M. Kay, Pearson 2. Detection, Estimation, and Modulation Theory, Part-1, Van Trees, Jhon Wiley **Reference Books:** 1. Signal Detection and Estimation, Second Edition, Mourad Barkat Artech house. 2. An Introduction to Signal detection and Estimation: H. Vincent Poor, Springer-Verlag

COURSE ARTICULATION MATRIX

Mapping of CO (Course outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	3	2	2	1	1	1	1	1	1	1	3	2	2
CO#2	3	3	3	2	1	1	1	1	1	1	1	1	3	2	2
CO#3	3	3	3	2	1	1	2	1	1	1	1	1	3	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE611	Information Theory and Coding	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) and End Assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	**CO.1** Understand the concept of Information and quantitative from of characterization of information. **CO.2** Understand abstraction of digital information transfer and characterize storage/transfer from mathematical viewpoint. **CO.3** Gain knowledge about techniques for information compression and its application **CO.4** Understand Channel Capacity and Shannon's Law on Information capacity. Appreciate information theoretic results as fundamental limits on performance of Communication systems. Analyze Capacity of Various Channels. **CO.5** Understand the fundamental difference between Source Coding theorem and Channel Coding theorem. **CO.6** Understand different approaches for error correction and suitability of their Application. Develop understanding of Block Coding.
Topics Covered	**Module 1: Information Theory** (9L) Introduction to information theory, uncertainty and information, entropy, relative entropy, mutual information, chain rules, differential entropy, properties of differential entropy, Jensen's inequality, data processing inequality. **Module 2: Source Coding** (8L) Source coding theorem, Kraft inequality, optimal codes, Huffman coding, Shannon-Fano-Elias coding, Lempel-Ziv coding, rate-distortion function. **Module 3: Channel Capacity and Coding** (10L) Channel models, channel capacity, binary symmetric channel (BSC), binary erasure channel (BEC), channel coding theorem, information capacity theorem, Shannon's limit, Gaussian channel, parallel Gaussian channel. **Module 4: Error Control Coding** (15L) Linear algebra fundamentals, linear block codes, generator matrix, parity-check matrix, encoding and decoding of linear block codes, syndrome decoding, Hamming code, properties of linear block codes. Cyclic codes: algebraic description, encoding and decoding of cyclic codes. Convolutional codes: definition, encoding, trellis and state representation, Viterbi decoding, error probability, and decoding via the Viterbi algorithm.
Text Books, and/or reference material	1. Information Theory Coding and Cryptography, Third Edition, Ranjan Bose, McGraw-Hill Education Pvt. Limited. 2. Elements of Information Theory , Thomas M.Cover and Joy.A. Thomas, Wiley 3. Error Control Coding, Fundamentals and Application Shu Lin, Daniel J. Costello, Pearson, India 4. Error Correction Coding Mathematical Methods and application, Todd K. Moon, Wiley, India.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	2	2	1	2	1	1	1	1	1	1	3	2	1
CO#2	3	2	2	2	1	2	1	1	1	1	1	1	3	2	1
CO#3	3	3	3	2	1	2	1	1	1	1	1	1	3	3	2
CO#4	3	2	3	2	1	1	1	1	1	1	1	1	3	3	2
CO#5	3	3	2	3	1	1	1	1	1	1	1	1	3	2	2
CO#6	3	3	2	3	1	1	1	1	1	1	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE612	Analog IC Design	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CA), Mid Term(MT) and End Term (ET))					
Semiconductor Devices and Technology (ECC302), Microelectronic Circuits (ECC404)		(CA+MT+ET=15+25+60=100)					
Course Outcomes	• **CO1:** Define various parameters/terms associated with MOS transistors and Analog IC design. • **CO2:** Describe the operation of a MOS transistor /Amplifier/other fundamental blocks. • **CO3:** Solve any given circuit using appropriate Large/Small Signal model equations. • **CO4:** Evaluate various performance metrics such as gain/BW/Power dissipation/Input & output range etc. • **CO5:** Analyze feedback circuit and determine its poles, zeros, gain margin & phase margin. • **CO6:** Design a Single stage Amplifier/Differential Amplifier to meet the given specifications.						
Topics Covered	**Module I: Introduction to MOS** (L – 04) MOS device physics – general considerations, overview of CMOS technology, MOS I/V characteristics, short channel effects, noise, large signal MOS device models. **Module II: Small Signal MOS Model** (L – 02) MOS device capacitance, small signal device models. Different transconductances (front gate: gmg_mgm, output: gdsg_{ds}gds, back gate: gmbg_{mb}gmb). Unity gain frequency calculation. **Module III: Basic MOS Amplifiers** (L – 08) Single-stage amplifiers – basic concepts, common source stage, source follower, common gate stage, cascode stage, calculation of amplifier parameters.						

	Module IV: Current Mirrors/References (L – 03) Current mirrors: simple, cascode, Wilson, wide-swing. **Module V: Frequency Response of Amplifiers** (L – 06) Frequency response of amplifiers – general considerations, common source stage, source followers, common gate stage, cascode stage, differential pair. **Module VI: Differential Amplifier** (L – 07) Differential amplifiers – single-ended and double-ended. Differential operation, basic differential pair, common-mode response, differential pair with MOS loads, current mirror load. **Module VII: Single Stage Opamps** (L – 07) Operational amplifiers – general considerations, single-stage op-amps, two-stage op-amps, input range limitations (ICMR), slew rate, noise and offset in op-amps. **Module VIII: Feedback** (L – 05) Feedback – types, Nyquist plot, stability, frequency compensation techniques, Miller compensation, pole splitting, gain margin, phase margin.
Text Books, and/or Reference material	**Text Books:** [1] Design of Analog CMOS Integrated Circuits, by Behzad Razavi, McGraw-Hill, 2014. [2] Adel Sedra, Kenneth C. Smith, Tony Chan Carusone, Vincent Gaudet, " *Microelectronic Circuits*", Oxford, 8th Ed. 2020 [3] Understanding Microelectronics: A Top-Down Approach by Franco Maloberti, Wiley (2011) **Reference Books**: [1]. Analysis and Design of Analog Integrated Circuit, Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, and Robert G. Meyer, John Wiley & Sons, Inc., 5th edition 2015 [2]. CMOS: Circuit Design, Layout, and Simulation by R. Jacob Baker, Wiley-IEEE Press(2019)
Video Lectures	**NPTEL/SWAYAM Video Lectures:** https://www.youtube.com/watch?v=2i2PMtRDvE8&list=PLuv3GM6-gsE0ix0s_d6JNIQXePzXr3_GZ Prof. Nagendra Krishnapura, IITM https://www.youtube.com/watch?v=pK2elUcXWzs&list=PLiDoPUX9nLkIw9EnIv_3K19wlcyJ6msYd [3]. Prof. Behzad Razavi, UCLA

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	1	3	3	1	1	1	1	1	1	1	2	2	2	1
CO#2	3	2	2	1	1	1	1	1	1	1	1	1	2	2	1
CO#3	3	3	3	1	1	1	1	1	1	1	1	1	3	3	2
CO#4	3	2	3	2	1	1	1	1	1	1	1	1	3	3	2
CO#5	2	3	1	1	1	2	2	1	1	1	1	1	2	3	1
CO#6	3	2	3	2	1	1	1	1	1	1	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE613	FPGA based Design	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous Assessment (CA: 15%), Mid-Term Assessment (MA: 25%) and End-Term Assessment (EA: 60%))					
Digital Circuits and Systems (ECC304), VLSI Design (ECC601)		Continuous Assessment (CA): Quizzes/Class tests/Assignments/Attendance					

Course Outcomes	**CO1:** Learn logic synthesis techniques – two-level and multilevel synthesis. **CO2:** Be able to design systems using FPGAs and CPLDs. **CO3**: Learn sequential machine design using FPGAs. **CO4**: Learn to design systems for low power operation.
Topics Covered	**Module-I:** (L – 04) Logic design fundamentals: Two level synthesis – SOP/POS forms, Logic minimization, Limitations of two-level synthesis, introduction to multi-level synthesis. **Module-II:** (L – 06) Programmable Logic Devices: Programmable Logic Array (PLA) architecture; Programmable Array Logic (PAL), PAL vs. PROM, Fan-in expansion feature, Architecture for sequential circuit implementation, Typical PAL chips; Complex Programmable Logic Devices (CPLD). **Module-III:** (L – 06) Programmable Gate Arrays: Gate Array concept, Mask programmable and Field Programmable Gate Arrays; Lookup tables (LUT) Configurable logic blocks (CLB), logic design using LUT's; Multi-level synthesis techniques – Factoring and Functional decomposition, Shannon's Expansion Theorem; Generalized FPGA Architecture; Introduction to CAD Tools for FPGA based design, design entry, and simulation – introduction to HDL, synthesis, post-synthesis simulation, interfacing external devices. **Module-IV:** (L – 08) Sequential Circuit Design: Finite State Machines, Moore and Mealy Machines; State diagrams, State table, State assignment, derivation of next-state and output expressions, state minimization; State assignment for low power operation; CAD tools for FSM synthesis; Designing a simple CPU, concept of embedded system. **Module-V:** (L – 02) Advanced features of modern FPGAs: Block RAMs, Embedded processor, Communication ports, Analog interface. **Module-VI:** (L – 06) FPGA as a Hardware Debugging platform: Hardware troubleshooting methods, Looking into the chip – Logic State Analyzer and its use; Concept of Hardware emulation – simulation vs. Emulation, FPGA as a Hardware emulator, Break-points and their utility, setting break-points in FPGA based design. **Module-VII:** (P – 8): Familiarizing with CAD tools, Design and synthesis of simple logic functions – Basic gates, adder/subtractor, decoder, encoder, multiplexer, demultiplexer; Interfacing external devices – setting user constraint file, interfacing input (switch) and output (LED) devices, BCD to seven-segment decoder, keyboard/display interface; designing memory elements and arrays; sequential machine design – sequence generators, timing generators, a typical machine design (example: vending machine); A simple CPU design, constructing a basic embedded system – interfacing on-chip CPU, memory and I/O ports.

	Module-VIII: (P – 2) Design analysis: Static timing analysis, Power analysis, Resource utilization, noise, clock network, DRC, debugging methods.
Text Books, and/or Reference Materials	**Text Books**: 1. S. Brown and Z. Vranesic, "Fundamentals of Digital Logic with Verilog Design," McGraw Hill Education Special India Edition (SIE), 2017. **Reference Book**: 1. J. Bhasker, "A Verilog HDL Primer", B.S. Publications, Hyderabad in arrangement with Star Galaxy Publishing, USA, 1999.

COURSE ARTICULATION MATRIX

Mapping CO (Course outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE614	MEMS and Microsystems Technology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) and End Assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: **Understand** characteristics of MEMS system CO2: **Understand** basic building blocks of general MEMS systems CO3: **Understand** synthesis and fabrication of MEMS system CO4: **Apply qualitative and quantitative analysis** techniques in general MEMS systems CO5: **Design** techniques in MEMS CO6: **Investigate complex designs** in MEMS systems						
Topics Covered	Fabrication process (5L) Lumped Modeling, Statics, Dynamics (5L) Quasi static analysis (3L) Elasticity, Structures (4L) Energy Methods (3L) Thermal Energy Domain, Fluids, Electronics (6L) Noise (2L) Feedback systems (2L) Integration of MEMS systems, Scaling effect (3L) Reliability of MEMS devices (2L) Case studies in MEMS (7L)						

Text Books, and/or reference material	**Text Book**: 1. Microsystem Design by Stephen D. Senturia, Springer **Reference Book**: 1. Micro and Smart Systems by K.J. Vinoy, S. Gopalakrishnan, K.N. Bhat, V.K. Aatre G.K. Ananthasuresh, Wiley

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#2	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#3	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#4	1	3	2	1	1	1	1	1	1	1	1	1	2	3	1
CO#5	1	1	3	2	1	1	1	1	1	1	1	1	2	3	1
CO#6	1	2	3	1	1	1	1	1	1	1	1	1	2	3	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE615	VLSI Process Technology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic Electrical and Electronics Engineering (XEC02), Semiconductor Devices and Technology (ECC302)		CT+MT+EA					
Course Outcomes	CO#1: Outline basic knowledge of semiconductor materials, devices and growth process of Si devices CO#2: Identify the process flow of device fabrication. CO#3: Illustrate the each process method of VLSI technology CO#4: Build the knowledge of integrated process technology						
Topics Covered	**Module 1: Introduction** (3L) Materials, definitions, scaling laws, idea of clean room, Si substrate growth, and cleaning of Si. **Module 2: Oxidation** (5L) Oxidation: process of oxidation, types of oxidation, Deal-Grove model, dependence of oxidation on different parameters, applications in IC technology, LOCOS. **Module 3: Lithography** (6L) Process flow of lithography, components of lithography, aligner (contact, proximity, projection), metrics of lithography, photoresist (positive and negative), mask, next-generation lithography.						

	Module 4: Diffusion and Ion Implantation (7L) Basic concepts, diffusion in Si and poly-Si, basic process: pre-deposition and drive-in diffusion, problems in thermal diffusion. Advantages of ion implantation, ion implantation system, mechanism, implantation profile, junction depth, dose and concentration relationship, ion implantation damage and annealing, ion channeling, multi-implantation. **Module 5: Thin Film Deposition** (6L) Requirements of deposition; methods: physical vapor deposition (PVD) and chemical vapor deposition (CVD); step coverage and filling issues. **Module 6: Etching** (3L) Etch process, requirements, figure of merits, types of etch, dry and plasma etch, ion-enhanced etch. **Module 7: Metallization and Interconnect** (6L) Interconnect and its requirements, possible interconnect materials, Al metallization, Al spike problem, hillocks and voids, electromigration problems and solutions, metal silicides, multilevel metallization, W plugs for contact and vias, intermetal dielectrics. **Module 8: IC Process Integration** (6L) Simple resistor, capacitor, NMOS.
Text Books, and/or reference material	1. VLSI Technology: S M Sze 2. Silicon Process Technology: S K Gandhi 3. Silicon VLSI Technology: Plummer, Deal and Griffin 4. Fundamental of Semiconductor Fabrication: Sze and May

COURSE ARTICULATION MATRIX

Mapping CO (Course outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR)/ Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE616	ASIC Design using Verilog/VHDL	PEL	3	0	0	3	3
Pre-requisites			Course Assessment methods: (Continuous Assessment (CA:15%), Mid-Term Assessment (MA:25%) and End-Term Assessment (EA:60%))				

Digital Circuits and Systems (ECC304)	Continuous Assessment (CA): Quizzes/Class tests/Assignments/Attendance

Course Outcomes

After successful completion of the course, the student will be able to:

- **CO 1:** Explain VLSI design flow using HDL.
- **CO 2:** Analyze and design combinational and sequential digital systems.
- **CO 3:** Employ EDA tools to model a digital system.
- **CO 4:** Write test benches to verify the design.
- **CO 5:** Compare between blocking and non-blocking statement and their uses.
- **CO 6:** Create a System from simulation to synthesizable design.

Topics Covered

Module I. Brief introduction to VLSI using CAD tools [L - 3]

Overview of Digital Design with Verilog HDL: Evolution of CAD, the emergence of HDLs, typical HDL-based design flow, Verilog HDL, Trends in HDLs.

Module-II. Hierarchical Modeling Concepts [L – 3]

Top-down and bottom-up design methodology, differences between modules and module instances, parts of a simulation, design block, stimulus block.

Module-III. Basic Concepts [L – 3]

Lexical conventions, data types, system tasks, compiler directives.Memory modeling Logic Synthesis: Introduction synthesis of different Verilog constructs.

Module-IV. Modules and Ports [L – 3]

Module definition, port declaration, connecting ports, hierarchical name referencing.

Module-V. Gate-Level Modeling [L – 2]

Modeling using basic Verilog gate primitives, description of and/or and buf/not type gates, rise, fall and turn-off delays, min, max, and typical delays.

Module-VI. Dataflow Modeling [L – 3]

Continuous assignments, delay specification, expressions, operators, operands, operator types.

Module-VII. Behavioural Modeling [L – 3]

Structured procedures, initial and always, blocking and nonblocking statements, delay control, generate a statement, event control, conditional statements, multiway branching, loops, sequential and parallel blocks

Module-VIII. Tasks and Functions [L – 4]

Differences between tasks and functions, declaration, invocation, automatic tasks, and functions.

Module-IX. Useful Modeling Techniques [L – 4]

Procedural continuous assignments, overriding parameters, conditional compilation and execution, useful system tasks.

Module-X. Flip-Flop and Counter Design [L – 4]

Synchronous and asynchronous flip flop design with set and reset, design of basic counters.

Module-XI. FSM & Processor Design [L – 6]

FSM modeling, Data path and Controller design, Modeling Memory, Pipelining, and Design of a Processor. Introduction to Reconfigurable computing, FPGAs, the Altera /Xilinx flow.

Module-XII. Essential System Verilog for UVM [L – 4]

Overview of basic SystemVerilog, UVM verification environment: introduction to UVM methodology and universal Verification Components (UVC) structure, stimulus modeling, creating a simple environment, DUT, TLM, functional coverage modeling, register modeling in UVM.

Text Books, and/or Reference Material

Text Books:

1. Samir Palnitkar, "*Verilog HDL, A Guide to Digital Design and Synthesis*", Second Edition, Pearson Education, 2004
2. J. Bhaskar, "*Verilog HDL Synthesis*", BS publications, 2001.

Reference Books/Materials:

1. S. Brown and Z. Vranesic, Fundamentals of Digital Logic with Verilog Design, McGraw Hill, Third Edition 2013.

	2. G. De Micheli. Synthesis and optimization of digital circuits, McGraw Hill, 2003 3. Indranil Sengupta, IIT Kharagpur, "*NPTEL Course on Hardware Modeling using Verilog*" (2017) https://www.youtube.com/watch?v=NCrlyaXMAn8&list=PLRsFfXmDi9IYCNlvNjrsD8bLMmNE0UxBH

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)														
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	1	3	2	1	1	1	1	1	1	1	1	1	2	3	1
CO#2	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#3	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#4	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#5	1	1	3	2	1	1	1	1	1	1	1	1	2	3	1
CO#6	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE617	RFID Technology and Applications	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and End Assessment (EA)):					
Signals and Systems (ECC303) Communication Systems I (ECC401) Communication Systems II (ECC501) Microwave and Antenna Engineering (ECC602) Analog IC Design (ECE612)		Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination					
Course Outcomes	**CO#1** Ability to understand the basic knowledge of the radio frequency identification technology. **CO#2** Ability to analyze, explain and resolve technical problems related to RFID technology for skills. **CO#3** Develop an ability to forming, planning, deployment, operation, and evaluation systems using RFID technology and complete real models.						
Topics Covered/ Syllabus	**Components Of RFID Systems And Performance Metrics**: Classification of RFID systems available, commercial specifications [L-6] **RFID Antenna and Tag Chip Design**: Design variants, developing matching elements, installation, environment [L-6]						

	Design of passive RFID tag: Passive RFID Operation; Passive RFID Reader Design [L-6] **RFID Middleware**: Concepts and Architecture, Data Management and Application-Level Events [L-6] **TAG identification protocols**, Tree-Based Anti-Collision Protocols for RFID Tags, Comparison of TTF and RTF UHF RFID Protocols , Techniques of RFID Positioning[L-6] **Reader Infrastructure Networking**, Integrating RFID Readers in Enterprise IT, reducing interference in networks, Optimal Tag Coverage and Tag Report Elimination, Secure and Privacy-Enhanced RFID Systems, Cryptographic Approaches for Improving Security and Privacy Issues of RFID Systems [L-6] **Energy Harvesting for Self-Powered Autonomous RFID Systems**, Tag Architecture Based on Energy Harvesting, Simulators and Emulators for Different Abstraction Layers of UHF RFID Systems [L-6]
Text Books, and/or Reference material	**Text Books:** 1. R Ludwig and P Bretchko, *RF Circuit Design: Theory and Application*, Pearson Education, New Delhi 2. Miles S,Sarma S,Wiiams J., (Eds.) (2008),RFID Technology and Applications, Cambridge: Cambridge University Press. Doi: 10.1017/CBO9780511541155 **Reference Book:** M. Bolic, D. Simplot-Ryl, I. Stojmenovic (Editors), *RFID Systems: Research Trends and Challenges*, John Wiley and Sons, 2010.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	3	2	-	-	-	-	-	-	-	2	3	2	2
CO#2	2	2	3	2	3	-	1	-	-	-	1	3	2	2	3
CO#3	2	2	3	2	1	-	-	-	-	-	-	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 40				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE618	Advanced Wireless Communication	PEL	3	0	0	3	3
Pre-requisites Communication system II (ECC501)			Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA))				

Course Outcomes	On successful completion of this course, students should have the skills and knowledge to : • **CO1:** Apply Cellular concepts to evaluate the signal reception performance in a cellular network and traffic analysis to design a cellular network with given quality of service constraints. • **CO2:** Determine the type and appropriate model of wireless fading channel based on the system parameters and the property of the wireless medium. • **CO3:** Analyze and design receiver and transmitter diversity techniques. Determine the appropriate transceiver design of multi-antenna systems and evaluate the data rate performance. • **CO4:** Application of Fundamental Digital Communication Concepts in Fading Channel. • Understanding suitable Modulation Schemes for the Wireless Channel • **CO5:** Describe and differentiate four generations of wireless standards for cellular networks. Understand wireless communication systems with key 3G (e.g., CDMA); 4G (OFDM) and 5G technologies
Topics Covered	**Module I: Introduction** (2L) Introduction to wireless personal communication, mobile radio systems, and an overview of 5G. **Module II: Cellular Systems Concepts** (6L) Cellular system concepts and principles, system design fundamentals, spectrum efficiency, frequency management, channel assignment, handoff, power control, call blocking, Erlang B, Erlang C, cell splitting, directional antennas, etc. **Module III: Wireless Channel Characterization** (8L) Characterization of wireless radio channel, propagation path models, fading and shadowing, statistical characterization of fading channels. **Module IV: Receiver Techniques and Diversity** (7L) Receiver techniques for fading channels, signal detection in fading channels, coherent and non-coherent detection, diversity techniques: time and frequency diversity, repetition code, receive diversity (SC, MRC, EGC, switch & stay), BER and outage with diversity, transmit diversity, Alamouti code, MIMO fundamentals, equalization, fading mitigation. **Module V: Capacity of Fading Channels** (4L) Capacity in slow fading channels, capacity with receive and transmit diversity, multi-user capacity. **Module VI: Modulation Techniques** (4L) Modulation schemes for wireless communication: MSK, GMSK, OFDM. **Module VII: Multiple Access Techniques** (5L) Spread spectrum techniques, cellular CDMA, wide-band CDMA, multiple access performance of CDMA, capacity of multiple access schemes, comparison of access methods, NOMA. **Module VIII: Wireless Networks and Standards** (6L) GSM, CDMA cellular standards, 3G, 4G, and 5G; challenges of 5G, key 5G technologies, design issues, spectrum, regulation, and standardization for 5G.
Text Books, and/or Reference materials	**Text Books:** [1] Andrea Goldsmith, "*Wireless Communication*", Cambridge University Press [2] Aditya K Jagannathan, "*Principles of Modern Wireless Communication Systems Theory and Practice"*, McGraw-Hill India. [3] David TSE and Pramod Viswanathan, "*Fundamentals of Wireless Communication*", Cambridge University Press **Reference Books:** [1] Theodore Rappaport, "*Wireless Communications: Principles and Practice*", Pearson, 2nd Edition [2] Andreas. F. Molisch, "*Wireless Communication*", John Wiley and Sons [3] Mark and Zhuang, "*Wireless Communication and Networking*", PHI [4] J. G. Andrews *et al.*, "*What Will 5G Be*?," in *IEEE Journal on Selected Areas in Communications*, vol. 32, no. 6, pp. 1065-1082, June 2014, doi: 10.1109/JSAC.2014.2328098.

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	1	3	3	1	1	1	1	1	1	1	2	2	2	1
CO#2	3	2	2	1	1	1	1	1	1	1	1	1	2	1	1
CO#3	3	3	3	1	1	1	1	1	1	1	1	1	3	3	2
CO#4	2	2	3	1	1	1	1	1	1	1	1	1	3	1	2
CO#5	2	3	2	1	1	1	1	1	1	1	1	1	2	2	1

COURSE ARTICULATION MATRIX

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE619	Digital Image Processing	PEL	3	0	0	3	3
Prerequisites		Course Assessment methods (Continuous (CT), Mid-Term (MT), End Assessment (EA))					
Signals and Systems (ECC303), Digital Signal Processing (ECC402), Digital Circuits and Systems (ECC304)		The assessment methods consist of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.					
Course Outcomes		CO1: Understand image enhancement and restoration techniques. CO2: Analyze digital images through multiresolution techniques. CO3: Understand the application of morphological processing and segmentation in digital images. CO4: Ability to interpret digital image recognition techniques.					
Topics Covered mapped to Course Outcomes		Topic Details				(No. of classes)	Course Outcomes (COs)
		Digital Image Fundamentals: Image acquisition, Sampling, Quantization, Resolution, Relationship between pixels, Geometric transforms, Convolution and Correlation.				4	CO#1
		Image Enhancement: Gray level intensity transforms, Histogram processing, Image sharpening and smoothening operations (spatial and frequency based).				6	CO#1
		Image Restoration: Model of image degradation, Noise models, Restoration in the presence of noise only spatial filtering, Periodic noise reduction by					

	frequency domain filtering, Estimating the degradation function, Weiner filtering, Constrained least squares filtering, Image interpolation and resampling.	6	CO#1
	Multi-resolution Image Processing: Short time Fourier transform, Wavelet function, Wavelet series, Discrete wavelet transform and multi-resolution analysis, Image decomposition and compression using discrete wavelet transform.	6	CO#2,CO#4
	Compression and Encoding of Image: Redundancy, Entropy coding, Lossy compression, Lossless compression, Quality preserving adaptive compression.	5	CO#1, CO#4
	Morphological Processing: Dilation and erosion, Opening and closing, Hit or Miss transform, Algorithms for feature extraction.	5	CO#3, CO#4
	Image Segmentation: Detection of discontinuities, Edge linking and boundary detection, Thresholding, Region based segmentation, Segmentation by morphological watersheds, Use of motion in segmentation.	6	CO#3, CO#4
	Patterns in Images and their Applications: Basics of features, Principal component analysis, Decision tree and feature hierarchy, Scale invariant feature transform, Histogram of oriented gradient.	4	CO#4
Text Books, and / or reference material	**Text Books**: 1. Digital Image Processing: R C Gonzalez and R E Woods; Pearson Education. 2. Guide to Signals and Patterns in Image Processing- Foundations, Methods and Applications: Apurba Das; Springer. 3. Digital Image Processing and Computer Vision: Sonka, Hlavac and Boyle; Cengage Learning (India Edition). **Reference Books**: 1. Digital Image Processing: K R Castleman; Pearson Education. 2. Digital Image Processing: S Sridhar; Oxford Higher Education.		

COURSE ARTICULATION MATRIX

Mapping of Course Outcome (CO) to Programme Outcome (PO) & Programme Specific Outcome (PSO)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	3	3	3	-	-	-	2	-	1	-	3	3	1
CO#2	3	3	3	3	3	-	-	-	2	-	1	-	3	3	1
CO#3	2	3	3	3	2	-	-	-	1	-	1	-	3	3	1
CO#4	2	2	3	3	3	-	-	-	2	-	1	-	3	3	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE620	Advanced Semiconductor Devices	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Semiconductor Devices and Technology (ECC302)	CT+MT+EA

Course Outcomes	**CO1** Understand state of the art in semiconductor device physics and electronic properties of semiconductor devices **CO2** Acquire in depth knowledge of advanced field effect transistors and its applications **CO3** Develop understanding about basic working principles of quantum well devices and heterojunction device simulations
Topics Covered	**Module I: (L – 10)** Electronic properties and technologies of semiconductor Devices : SiGe and Group III-V compound semiconductors; Advanced Heterojunction bipolar Transistor (HBT) Devices: SiGe, GaAs, InP, GaN **Module II: (L – 10)** Advanced Field Effect Devices: Heterostructure Field Effect Transistors (HFETs), Modulation Doped Field Effect Transistors (MODFETs), High Electron Mobility Transistors (HEMTs) **Module III: (L – 4)** Resonant Tunneling Devices (RTDs); Single Electron Transistors (SETs) **Module IV: (L –10)** Strained layer superlattices and quantum well devices; RF & digital applications; Noise Characteristics **Module V: (L –8)** HBT Modelling; Heterojunction device simulation
Text Books, and/or reference material	1. Theory of Modern Electronic Semiconductor Devices, Kevin F. Brennan, April S. Brown, 2002 John Wiley & Sons, Inc. 2. Physics of Semiconductor Devices, S.M. Sze, Wiley, 1981 3. GaAs High-Speed Devices: Physics, Technology, and Circuit Applications, C.Y. Chang, F. Kai, Wiley, 1994 4. Device Electronics for Integrated Circuits, R. S. Muller & T. I. Kamins, Wiley, 2003 5. Silicon VLSI technology: fundamentals, practice and modelling, J. D. Plummer, M. D. Deal, P. B. Griffin, Pearson Education, 2009

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	3	2	-	-	-	-	-	-	-	2	3	2	2
CO#2	2	2	3	2	3	-	1	-	-	-	1	3	2	2	3
CO#3	2	2	3	2	1	-	-	-	-	-	-	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE621	Random Process	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), Mid-Term (MT), End Assessment (EA))
NIL	CT+MT+EA

Course Outcomes	CO1: Characterize probability models and function of random variables. CO2: Evaluate and apply moments & characteristic functions and understand the concept of inequalities and probabilistic limits. CO3: Recognize, interpret and apply a variety of deterministic and nondeterministic random processes that occur in engineering. CO4: Calculate the autocorrelation and spectral density of a random process and recognize the relation beteen them.
Topics Covered	1. Introduction: Basic of Probability theory, Bernoulli's Trials (5L) 2. Random Variables: PDF, PMF, Function of one random variable,Mean, Variance, Moments, Characteristics functions of random variables (10L) 3. Two random variables, Joint density and distribution function, Two functions of two random variables (8L) 4. Stationary random processes, Autocorrelation function, Cross correlation function, Covariance, PSD (7L) 5. Linear systems with random inputs (3L) 6. Markov Processes, Markov chain, CTMC, DTMC (4L) 7. Poisson process, Poissson distribution, Gaussian process (5L)
Text Books, and/or reference material	**Text Books**: 1. A. Popoulis, U. Pillai, *Probability, random variables and stochastic processes*, Tata McGraw-Hill Inc., 4th Ed., New Delhi, 2017 2. P. Peebles, *Probability, random variables and random signal priniciples*, McGraw-Hill Inc., 4th Ed., New York, USA, 2001 3. C. W. Therrien, M. Tummala, *Probabilty and random processes for electrical and computer engineers*, 2nd Ed., CRC press, printed in India, 2012 **Reference Books**: 1. George R. Cooper, C. D. McGillem, *Probabilistic methods of signal analysis and system analysis*, Oxford University Press, 3rd Ed. , New Delhi, 2007 2. Alberto Leon-Garcia, *Probability and random processes for electrical engineering*, Pearson Education Inc., 2nd Ed., 2007

Mapping the Course Outcome (CO) to Programme Outcome (PO) and Programme Specific Outcome (PSO)

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

COURSE ARTICULATION MATRIX

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR)/ Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECE622</td><td>Biostatistics in Network Analysis</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites: NIL</td><td colspan="5">Course Assessment methods: (Continuous Assessment (CA:15%), Mid-Term Assessment (MA:25%) and End-Term Assessment (EA:60%))</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After the completion of the course, the student will be able to:
CO1: Understand fundamental statistical distributions and methods.
CO2: Apply the fundamental distributions in implementing linear models, contingency tables, graphical and bootstrap estimation techniques useful to unravel complicated network problems.
CO3: Understand the descriptions of non-parametric methods and regression models specifically designed to analyze survival data networks.
CO4: Explore statistical methods for analysis of epidemiologic networks.
CO5: Apply the statistical methods to identify the consequences of non-random mating.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I. Basics of Statistical Distributions [L-8]
Normal distribution, t-distribution, Chi-square probability distribution, f-distribution, Uniform probability distribution, p-value, Four properties of an estimated confidence interval, Ratios and weighted averages, Estimates weighted by reciprocal variances, Discrete probability distributions- Binomial, Poisson, Geometric, Correlations- Spearman’s rank correlation coefficient, Point bi-serial correlation coefficient, Gamma coefficient, Chi-Square based measures of association.
Module II. Application Models [L-8]
Linear Bivariate Regression model, Wilcoxon Rank Sum Test, Non-parametric analysis of a 2×k table, Chi-square analysis of a 2×k table, Log-linear Poisson Regression model, Two-way and Three-way tables and their analysis, Bootstrap analysis, Graphical analysis, Test of variance, Analysis of Variance, Two sample Test of Variance, F-Ratio Test of Variance, Bartlett’s Test of Variance, Levene’s Test of Variance, Siegel-Tukey Two Sample Test of Variance, Wilcoxon Signed Rank Test, Kruskal-Wallis Nonparametric comparison of k sample mean values, Three group regression analysis, Tukey’s Quick Test, Friedman Rank Test.
Module III. Survival Analysis [L-8]
Non-parametric survival analysis- cumulative hazard function, the log-rank test, Cox analysis of proportional hazard models, Two sample and multivariable Weibull Survival time model.
Module IV. Epidemiologic Analysis [L-8]
Net Reclassification Index, Integrated Discrimination Improvement, Incidence rates, Two Risk factors, Adjustment through stratification, Knox’s time space method, Mantel’s time space regression method, ROC curve and its non-parametric estimation.
Module V. Genetic Analysis [L-8]
Balanced Polymorphism, Mendelian Segregation Analysis, Admixed Population, Non-Random Mating,</td></tr>
<tr><td>Text Books, and/or Reference Material</td><td colspan="7">Text Book:
1. Steve Selvin, "A Biostatistics Toolbox for Data Analysis", Cambridge University Press, 1st Ed., 2015.
Reference Book:
1. A Gouveia Oliveira, "Biostatistics Decoded", John Wiley and Sons, 1st Ed., 2013.</td></tr>
</table>

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO# 1**	**PSO# 2**	**PSO #3**
CO#1	2	1	3	3	1	1	1	1	1	1	1	2	2	2	1
CO#2	3	2	2	1	1	1	1	1	1	1	1	1	2	1	1
CO#3	3	3	3	1	1	1	1	1	1	1	1	1	3	3	2
CO#4	2	2	3	1	1	1	1	1	1	1	1	1	3	1	2
CO#5	2	3	2	1	1	1	1	1	1	1	1	1	2	2	1

COURSE ARTICULATION MATRIX

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE623	Biomedical Instrumentation	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and End Assessment (EA))					
Basic Electrical and Electronics Engineering (XEC02), Engineering Mechanics (XEC01)		Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination					
Course Outcomes	After the completion of the course the student will be able to **CO 1**: Understand concept of Biomedical Instrumentation **CO 2**: Understand basic building blocks of Biomedical Instruments **CO 3**: Apply quantitative analysis techniques to Biomedical Instruments **CO 4**: Learn design techniques of Biomedical Instruments **CO 5**: Investigate application specific Biomedical Instruments						
Topics Covered	**Module I: Introduction to Biomedical Measurements and Instrumentation [L-1]** **Module II: Static and dynamic characteristics of Biomedical Instruments [L** Static characteristics of elements, Dynamic characteristics of elements, Quasi- static characteristics of elements, Static characteristics of systems, Dynamic characteristics of systems, linearity, non-linearity, Sensitivity, Resolution, Repeatability, Reproducibility, Response time, Settling time, Gain, bandwidth **Module III: Error and Noise in Biomedical Measurements [L-4]** Sources of noise in measurement systems, mathematical modelling of noise, environmental effects, Effects of Interfering and Modifying inputs, Error analysis, Systematic error, Random error. Statistical methods for noise and error analysis and Modelling. **Module IV: Reliability analysis of Biomedical Instruments [L-4]** Concept of Reliability, Reliability of measurement systems, Reliability enhancement strategies **Module V: Operation of Physiological organs, Bioelectric Potentials and Electrodes [L-7]** Operation of Physiological organs, Operation of Nerves system, Operation of heart, Operation of lungs, Operation of Muscular system, Sources of bioelectric potentials, Bioelectric electrodes						

	Module VI: Building blocks of Biomedical Instruments [L-9] Bioelectric sensors, Sensors, Signal conditioning circuits, Bridge circuits, Amplifiers, Filters, Oscillators, ADC, Signal Processing Units, Microcontrollers, Data Presentation elements **Module VII: Application Specific Biomedical Instruments [L-10]** Clinical thermometer, Sphygmomanometer, Digital Statoscope, ECG signal measuring instrument, EEG signal measuring instrument, Medical Imaging techniques, Assistive Respiratory system
Text Books, and/or reference material	**Text Books:** 1. John G. Webster, *Medical Instrumentation Application and Design*, 4ed, Wiley, 2015 2. J. Bentley, *Principles of measurement systems*. Pearson Education India; 3rd edition, 2002 3. R.S. Khandpur, *Handbook of Biomedical Instrumentation*, 3rd Edition, McGraw Hill Education;, 2014 **Reference Material:** 1. Research Articles

COURSE ARTICULATION MATRIX

Mapping CO (Course Outcome) to
PO (Programme Outcome) and PSO (Programme Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE624	Quantum Computing, Communication, and Security	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
ECC601 (VLSI Design) ECC501 (Communication Systems II) ECC502 (Computer Organization and Architecture)		CT+EA					
Course Outcomes	**CO1: Analyze** and **design** quantum logic gates and circuits. **CO2: Understand** quantum parallelism and **formulate** quantum algorithms. **CO3: Describe** quantum networks and their integration with classical networks. **CO4: Analyze** side-channel attacks and QKD protocols.						
Topics Covered	**Module 1: Quantum bits and quantum gates [8 hrs.]** Qubit - Bloch sphere representation, two qubits.						

	NMR, trapped ion, solid state spin. Quantum gates – Unary, NOT, CNOT, Toffoli, universal Gates, Bell state circuit. **Module 2: Quantum algorithms [10 hrs.]** Quantum parallelism, computational complexity. Deutsch's algorithm. Grover algorithm. DiVincenzo criteria **Module 3: Quantum communication [8 hrs.]** Remote entanglement, teleportation. Quantum networks and applications, co-existence of classical and quantum data in the same channels. Fibre-based, satellite and drone-based quantum communication Quantum error correction **Module 4: Quantum security [10 hrs.]** Shor Algorithm, quantum Fourier transform. Side-channel attacks, detector blinding, faked states attack, countermeasures. Quantum key distribution. BB84 protocol, Ekert91 protocol.
Text Books, and/or reference material	Text Books: 1. Quantum Computation and Quantum Information – M. A. Nielsen, I. L. Chuang (Cambridge). 2. Introduction to Quantum Computing – R. LaPierre (Springer). 3. Quantum Information, Computation and Communication – J. A. Jones, D. Jaksch (Cambridge). Reference Books: 1. Quantum Computing for Everyone – C. Bernhardt (MIT Press). 2. Concise Guide to Quantum Computing Algorithms, Exercises, and Implementations - S. Kurgalin, S. Borzunov (Springer). 3. Quantum Computing: A Gentle Introduction – E. Rieffel, W. Polak (MIT Press). 4. Quantum Private Communication – G. Zeng (Springer).

Mapping of CO (Course outcome) and PO (Programme Outcome) and PSO (Program Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SEVENTH SEMESTER

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MSC731	PRINCIPLES OF MANAGEMENT	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and End Assessment (EA))					

Course Outcomes	• CO1:To make budding engineers aware of various management functions required for any organization • CO2:To impart knowledge on various tools and techniques applied by the executives of an organization • CO3:To make potential engineers aware of managerial function so that it would help for their professional career • CO4:To impart knowledge on organizational activities operational and strategic both in nature • C05: To impart knowledge on each functional area of management like Marketing, Finance, Behavioral Science, Quantitative Techniques and Decision Science
Topics Covered	**UNIT I:** Management Functions and Business Environment: Business environment-macro, Business environment -micro; Porter's five forces, Management functions – overview, Different levels and roles of management, Planning- Steps, Planning and environmental analysis with SWOT, Application of BCG matrix in organization **(12)** **UNIT II:** Quantitative tools and techniques used in management: Forecasting techniques, Decision analysis **(6)** **UNIT III:** Creating and delivering superior customer value: Basic understanding of marketing, Consumer behavior-fundamentals, Segmentation, Targeting & Positioning, Product Life cycle. **(8)** **UNIT IV:** Behavioral management of individual: Motivation, Leadership, Perception, Learning. **(8)** **UNIT V:** Professional ethics: Introduction to Professional ethics, Morals, values and Ethics, Ethics in Business**. (2)**
Text Books, and/or reference material	Text Books: 1. Marketing Management 15th Edition, Philip Kotler and Kelvin Keller, Pearson India 2. Management Principles, Processes and practice, first edition, Anil Bhat and Arya Kumar, Oxford Higher education 3. Organizational Behavior,13 th edition, Stephen P Robbins, Pearson Prentice hall India 4. Operations Management, 7th edition (Quality control, Forecasting), Buffa & Sarin, Willey 5. A.C. Fernando: Business Ethics & Corporate Governance, Pearson Education 2nd edition

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	1	3	3	1	1	1	1	1	1	1	2	2	2	1
CO#2	3	2	2	1	1	1	1	1	1	1	1	1	2	1	1
CO#3	3	3	3	1	1	1	1	1	1	1	1	1	3	3	2
CO#4	2	2	3	1	1	1	1	1	1	1	1	1	3	1	2
CO#5	2	3	2	1	1	1	1	1	1	1	1	1	2	2	1

COURSE ARTICULATION MATRIX

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS751	Electronic System Design Lab	PCR	0	0	3	2	2
Pre-requisites: Semiconductor Devices and Technology (ECC302) Microelectronic Circuits (ECC404)		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Course Outcomes	CO1: Understand experimental design procedure CO2: Develop troubleshooting techniques CO3: Design electronic systems focusing on applications CO4: Develop skill to use modern engineering software tools						
Topics Covered	1. Introductory class on Application Specific System Design, System Fabrication and Troubleshooting techniques 2. Design and Development of a Regulated DC power supply 3. Design and Development of LDR sensor driven application circuits, Design and Development of Actuator Driver circuit for controlling DC Motors 4. Design and Development of Electronic signal amplifiers 5. Design and Development of Low pass, High pass, Band pass Filter 6. Arduino microcontroller development board and its integrated operation using LDR and DC motor 7. Integration of Arduino microcontroller development board with Python for Sensor interfacing, data acquisition and Actuator control 8. Android Application Development for operating Functional Circuits integrated with Arduino microcontroller development board						
Text Books, and/or reference material	TEXT BOOKS 1. Principles of Measurement Systems, John Bentley, Pearson 2. Electronic Circuits: Analysis and Design by Donald A Neamen 3. Mechatronics, by W. Bolton, Fourth Edition, Pearson 4. Digital Fundamentals by Floyd 5. Laboratory Experiments manual						

COURSE ARTICULATION MATRIX

Mapping of CO (Course outcome) and PO (Programme Outcome) and PSO (Program Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SEVENTH SEMESTER DEPTH ELECTIVES

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE710	Statistical and Machine Learning Approaches for Network Analysis	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA))
Graph Theory, Artificial Intelligence and Machine Learning (ECC504), Statistical Signal Processing (ECE521)	Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination

Course Outcomes	After the completion of the course, the student will be able to: **CO1:** Understand the onset, progression, and intervention in complex networks through graph theory and machine learning techniques. **CO2:** Analyze the large scale signal generation and propagation in complex networks. **CO3:** Extract useful information regarding system properties to investigate the network's structure and function.
Topics Covered	**Module I. Computational Approaches to reconstruct and partition complex networks [L-6]** Reconstruction of directed networks (Boolean Networks, Probabilistic Boolean Networks, Bayesian Networks, Collaborative Graph Model, Expectation-Maximization based Approach), Reconstruction of undirected networks (Relevance Networks, Graphical Gaussian Models), Partitioning undirected networks (Kernighan-Lin Algorithm, Girvan-Newman Algorithm, Newman's Eigenvector method, Infomap, Clique Percolation method), Partitioning directed networks (Newman's Eigenvector method, Infomap, Clique Percolation method) **Module II. Introduction to Complex Networks [L-5]** Classical network, Scale free network, Small world network, Clustered network, Hierarchical modularity, Network motif, Assortativity, Reciprocity, Weighted networks, Network complexity, Centrality. **Module III. Modeling for Evolving Networks [L-5]** Unified evolving network model comprising reproduction of heterogeneous connectivity, hierarchical modularity, and disassortativity, Modeling without parameter tuning, Bipartite relationship (case study for metabolite distribution). **Module IV. Modularity Configuration in Complex Networks with Embedded Dynamics [L-3]** PIN Fragmentation, PIN Topology, Community Maps, Core Structures, Network Entropy **Module V. Influence of Statistical Estimators on the Large Scale Causal Inference of Regulatory Networks [L-3]** Conservative Causal Core, Estimating Mutual Information, Ensemble data and Local network based measures, Global network inference performance, Local network inference performance. **Module VI. Structure of an Evolving Random Bipartite Graph [L-6]** Structure of sparse bipartite graph, Enumerating bipartite graphs, Asymptotic expansion via Saddle Point Method. **Module VII. Graph Kernels [L-8]** Convolution Kernels, Random Walk Graph Kernels, Path based Graph Kernels, Tree Pattern Graph Kernels, Cyclic Pattern Kernels, Graphlet Kernels, Optimal Assignment Kernels, Neighborhood Hash Kernels, Complement Graph Kernels, Fingerprint Kernels, Matching based Kernels, Applications in Bio- and Cheminformatics.

	Module VIII. Density based Set Enumeration in Structured Data [L-6] Unsupervised pattern discovery in structured data, Dense cluster enumeration in weighted interaction networks, Dense cluster enumeration in higher order association data.
Text Books, and/or Reference materials	**Text Book:** 1. Matthias Dehmer & Subhash C. Basak, "*Statistical and Machine Learning Approaches for Network Analysis*", Wiley, 1st Ed. 2012. 2. S Janson, T Lukzak, & A Rucinski, "*Random Graphs*", Wiley, New York, 2000. **Reference Books:** 1. R J Tocci & R S Widmer, "*Digital Systems: Principles and Applications*", Prentice Hall, 8th Ed., 2001. 2. M E J Newman, "*Networks: An Introduction*", Oxford University Press, Oxford, 2010.

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	1	3	3	1	1	1	1	1	1	1	2	2	2	1
CO#2	3	2	2	1	1	1	1	1	1	1	1	1	2	1	1
CO#3	3	3	3	1	1	1	1	1	1	1	1	1	3	3	2

COURSE ARTICULATION MATRIX

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE711	Mixed Signal IC Design	PEL	3	0	0	3	3
Pre-requisites			Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA))				
Analog IC Design (ECE612) Digital IC Design (ECE520)			Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination				
Course Outcomes	After the completion of the course, the student will be able to: **CO1:** Explain the operation of various High performance OTAs/Opamps. **CO2:** Design Analog Circuits using gm/ID techniques. **CO3:** Create the Layout of a CMOS Mixed Signal System. **CO4:** Analyze a Comparator. **CO5:** Interpret the use of Switched Capacitor Circuits in Sampled data Systems **CO6:** Compare Data converter architectures based on Area/Power/Speed.						
Topics Covered	**Module I. Introduction [L – 9]** Overview of Mixed-Signal Design flow. Design of high performance Fully Differential Opamps: Telescopic cascode, Folded cascode, two-stage, Rail-to-Rail, Gain boosted OTAs/Opamps, Comparison.						

	Module II. g_m over I_D Design Process [L – 4] g_m over I_D technique: Transconductor efficiency in subthreshold, moderate and strong inversions. Various design plots: g_m/I_D, g_m/g_{ds}, f_T etc., and their use in Analog Design. Design of a CS Amplifier, and Two stage Opamp using g_m/I_D technique. **Module III. Opamp performance Metrics: [L – 2]** Slew rate & Settling time, CMRR, PSRR, Linearity, Distortion, Offset Cancellation techniques. **Module IV. Layout Techniques [L – 3]** Layout Techniques: Introduction to CMOS process, CMOS Layers, Design rule basics, DRC, LVS, Passive and Transistor layout, Fingering, Interdigitization. Matching components: Common centroid, Use of Dummy. Matching error, error propagation. **Module V. Switched Capacitor Circuits [L – 5]** Basic philosophy of Switched capacitor circuits, design of switched-capacitor amplifiers and integrators, 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. **Module VI. Sample and Hold [L – 4]** Operation of sample and holds circuits and theirs non-idealities. Comparators: Opamp based, Strong Arm Regenerative Latch, Latch dynamics, Offset reduction. **Module VII. Data Converters [L – 12]** Fundamentals of data converters; Introduction to data converter metrics: SNR, DNL, INL, Offset & Gain Error, SINAD, ENOB, SFDR, SDNR, Settling time etc. Nyquist rate D/A converters - voltage, current and charge mode converters, hybrid and segmented converters. Nyquist rate A/D converters (Flash, interpolating, folding flash, SAR and pipelined architectures) **Module VIII. Phase Locked Loop [L – 3]** Basic PLL topology, dynamics of simple PLL, Multiplier, phase detectors, lock acquisition, Phase frequency detector, Loop filters, Charge Pump PLLs.
Text Books, and/or Reference materials	**Text Books:** 1. Behzad Razavi, "*Design of Analog CMOS Integrated Circuits*", McGraw Hill, 2nd Ed. 2017 2. Tony Chan Carusone; David Johns; Kenneth Martin, "*Analog Integrated Circuit Design*", Wiley, 2nd Ed. 2013, 3. Behzad Razavi, "*Principles of Data Conversion System Design*", Wiley-IEEE Press, 1994 4. Adel Sedra , Kenneth Smith Tony Chan Carusone, Vincent Gaudet, "*Microelectronic Circuits*", Oxford ; 8th Ed.; 2020 **Reference Books/Materials:** 1. R.Gregorian, "*Introduction to CMOS Opamps and comparators*", Wiley, 1999 2. Rudy J. Van De Plassche, "*CMOS Integrated Analog-to-Digital and Digital-to-Analog Converters*", Springer, 2nd Ed. 2003. 3. Ali Hajimiri, Caltech, "*New Analog Circuit Design"*, https://www.youtube.com/watch?v=403CnTftB4M&list=PLc7Gz02Znph-c2-ssFpRrzYwbzplXfXUT

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	Credit
ECE712	Multidimensional Signal, Image, and Video Processing	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA))
Digital Signal Processing (ECC402), Information Theory and Coding (ECE610)	Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination

Course Outcomes	After the completion of the course, the student will be able to: **CO1: Understand** the 2 D signal processing. **CO2: Design and implement** 2 D image enhancement masks and restoration filters. **CO3: Design and implement** 3 D or spatio-temporal enhancement masks and restoration filters. **CO4: Understand** motion estimation and segmentation. **CO5: Design** robust networks for network video.
Topics Covered	**Module I. Two Dimensional Signals and Systems [L-6]** 2 D signals and discrete space systems, 2 D convolution, 2 D sampling, 2 D discrete space Fourier Transform, 2 D discrete cosine transform, Wavelet transform. **Module II. Two Dimensional Filter Design [L-5]** FIR Filter design, IIR Filter design, Wavelet Filter design. **Module III. Image Enhancement and Restoration [L-5]** Simple image processing filters, Linear and Median filtering, Edge detection, Edge linking, Segmentation, 2 D random field, 2 D recursive estimation, Inhomogeneous Gaussian estimation, Estimation in wavelet domain, Bayesian and Maximum *a Posteriori* estimation, Expectation Maximization, Non-Bayesian methods, Image Super-resolution. **Module IV. Digital Image Compression** DCT, SWT, DPCM, Optimal MSE quantization, Vector quantization, LBG algorithm, Entropy Coding, DCT coder, SWT coder, JPEG 2000, Directional transforms. **Module V. Three Dimensional and Spatiotemporal Processing** 3 D Signals and systems, 3 D sampling and reconstruction, Spatiotemporal signal processing, Spatiotemporal Markov models. **Module VI. Digital Video Processing** Inter-frame processing, Motion estimation and compensation, Motion compensated filtering, Bayesian method for estimating motion, Restoration of degraded video and film, Super-resolution of video. **Module VII. Digital Video Compression** Intra-frame coding, Inter-frame coding, Inter-frame SWT coders, Scalable video coders, H.264/AVC, H.264/SVC, H.264/MVC, Non-local intra-prediction, Object based coding. **Module VIII. Video Transmission over Networks** Video on IP networks, Robust SWT video coding, Error resilience features of H.264/AVC, Joint source network coding,
Text Books, and/or Reference materials	**Text Book:** 1. John W Woods, "*Multidimensional Signal, Image, and Video Processing and Coding*", Academic Press, 2nd Ed. 2012. **Reference Book:** 1. A L Bovik, "*Handbook of Image and Video Processing*", Elsevier/Academic Press, 2nd Ed., 2005.

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	1	3	3	1	1	1	1	1	1	1	2	2	2	1
CO#2	3	2	2	1	1	1	1	1	1	1	1	1	2	1	1
CO#3	3	3	3	1	1	1	1	1	1	1	1	1	3	3	2
CO#4	2	2	3	1	1	1	1	1	1	1	1	1	3	1	2
CO#5	2	3	2	1	1	1	1	1	1	1	1	1	2	2	1

COURSE ARTICULATION MATRIX

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 48				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE713	Satellite & Radar Engineering.	PEL	3	0	0	3	3
Pre-requisites		Course Assessment Methods (Continuous (CT), Mid-Term (MT), and End Assessment (EA))					
Electromagnetic Theory and Transmission Lines (ECC403), Microwave and Antenna Engineering (ECC602), Communication system I(ECC401) and Communication system II (ECC501)		Assignments, Mid-Semester and End-Semester Examination					
Course Outcomes	CO#1 Compute satellite orbit parameters, design and classify orbits based on Kepler's six elements, and understand the concepts of satellite launching and orbital positioning CO#2 Perform computations of link design and classify different losses in propagation for space communication. CO#3 Assimilate the concept of multiple access techniques in satellite communication and develop the ability to classify its various applications CO#4 Demonstrate and analyze the basic principles of radar system and navigation. CO#5 Analyze the effects of clutter, weather, and interference on radar performance, and explain the operation of electronically scanned radar systems						

Topics Covered	Module I Wireless channel and propagation, the basic RF link, satellite links (up and down) , optimization RF link, inter-satellite link, noise temperature, Antenna temperature, overall system temperature, propagation factors, rain attenuation model. Tropospheric and Ionospheric effect, signal-to-noise ratio [L-6] Module II Satellite Basic concepts, Frequency allocation for satellite services, orbital & spacecraft problems, comparison of networks and services, modulation techniques used for satellite communication. Spectrum Management. orbital mechanics, geostationary orbit, change in longitude, orbital manoeuvres, orbital transfer, and orbital perturbations. Launch Vehicles- principles of Rocket propulsion, powered flight, Launch vehicles for communication satellite [L-11] Module III Satellite subsystems and satellite link design: Altitude and orbit control (AOC) Subsystem, TT&C, power system, spacecraft antenna, transponder, Friis transmission equation, G/T ratio of earth station. Multiple access: FDMA, TDMA, CDMA techniques, comparison of multiple access techniques, error connecting codes. Application of satellite in remote sensing: Basic of remote sensing, Electromagnetic Radiation principles, Atmospheric window, Indian satellite sensing satellite system, Active, Passive, ground based and space based remote sensing. [L-15] Module IV Basic Radars, classification of Radars, Radar Block Diagram and Operation, Radar Frequencies and Applications. Radar Equation, signal to noise ratio, Probability density function, Radar cross section of targets, target models, PRF, system losses CW and FMCW radars: MTI radars, Delay lines and cancellers., range gating, AMTI, Tracking radar. Tracking performance [L-9] Module V. Radar transmitters and receivers: Magnetron Oscillator, Hard tube and live pulser. .Mixer amplifiers, receiver noise and Duplexers . Displays and Navigation : Clutter, Weather and Interference. Electronically scanning Radar system . Principles of radio aids to navigation. [L-7]
Text Books, and/or reference material	**Text Books:** [1] Dennis Roddy, *Satellite Communication*, 4/e, McGraw-Hill [2] Pratt and Bostian, *Satellite Communication*, 2/e, John Wiley and Sons. [3] Louis J. Ippolito, Jr.*Satellite Communications Systems Engineering: Atmospheric Effects, Satellite Link Design and System Performance*, Second Edition, John Wiley. [4] Introduction to Radar Systems, Skolnik, McGraw Hill, 3rd Edition, 2001. **Reference Books:** [1]. Recommendation ITU-R P.618-11, P Series Radio Wave Propagation. [2]. Floyd F. Sabins, *Remote Sensing: Principles and Interpretation*, 3rd edition (August 1996), W H Freeman & Co. [3]. Tri T Ha, *Digital Satellite Communication*, McGraw-Hill [4]. Radar: Principles, Technology, Applications- Byron Edde, Pearson Education, 2004. [5]. Radar Handbook ' Ed. By M.I Skolnik, 2 nd Edition, Tata McGraw-Hill.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 46</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECE714</td><td>RF IC Design</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA))</td></tr>
<tr><td colspan="3">Communication Systems I (ECC401) and Communication Systems II (ECC501),
Signals and Systems (ECC303),
Analog IC Design (ECE612)</td><td colspan="5">Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through the course, student will be able to
CO1: Analyze various architectures of today’s digital radio transmitters and receivers.
CO2: Analyze and design basic RF building-blocks in CMOS technology.
CO3: Define basic RF measurements parameters such as S-parameters, sensitivity, noise figure, IIP3
CO4: Assimilate the design techniques VCO, LNA as well as other front-end circuits</td></tr>
<tr><td>Topics Covered/ Syllabus</td><td colspan="7">Module-I: Introduction to RF IC Design Concepts [L – 6]
Basic Concepts in RF Design, passive on chip components and layouts, transceiver architectures, circuit analysis techniques at radio frequencies.
Module-II: Semiconductor radio frequency components [L – 8]
RF diodes, MOS transistor, determination of model parameters, parasitics of MOS transistors and high frequency behaviour of basic amplifier.RF Transistor Materials – The Transistor Equivalent Circuit – Y Parameters – S Parameters – Understanding RF Transistor Data Sheets; BSIM3 parameters of NMOS and PMOS transistors, matching and biasing networks for transistors
Module-III: Noise and non-linearity. [L – 4]
Noise Figure and representation of non-linearity, intermodulation products and intercept points
Module-IV: Filter Design [L – 4]
Resonator and filter configurations, realization of filter for specific transfer function, implementation of filters a coupled line filter.
Module V:RF Transistor Amplifier[L – 8]
Stability consideration, constant, gain and noise figure circles. Low Noise Amplifiers: SNR, LNA topologies, power constrained CMOS LNA design, low-current CMOS inverter LNAs, low-voltage LNA topologies, differential LNA design methodology, process variation in tuned LNAs, impact of temperature variation in tuned LNAs, low-noise bias networks for LNAs, MOSFET layout of LNA.
Module-VI: RF Mixers [L – 6]
Basic design concepts, single end diode mixer single balanced and double balanced diode mixer design. Transistor mixers, , conversion loss.
Module-VII: RF Oscillators [L – 6]

Basic Principles, Phase Noise, negative resistance oscillators, transistor oscillators, VCO design methodology, frequency scaling of CMOS VCO, VCO layoutPhase lock loops, frequency synthesizers</td></tr>
</table>

	Module-VIII:RF power amplifiers [L – 4] Class A, AB, B, C, D, E and F amplifiers, modulation of power amplifiers, linearity considerations
Text Books, and/or Reference material	**Text Books:** 1. R Ludwig and P Bretchko, *RF Circuit Design: Theory and Application*, Pearson Education, New Delhi. 2. Sorin Voinigescu,*High Frequency Integrated Circuits*, Cambridge Univeity Press,UK, 2013. **Reference Books:** 1. Behzad Razavi, RF Microelectronics Prentice Hall of India, 2001 2. Thomas H. Lee, The Design of CMOS Radio Frequency Integrated Circuits, Cambridge University Press.

COURSE ARTICULATION MATRIX

Mapping of Course Outcome (CO) to Programme Outcome (PO) and Programme Specific Outcome (PSO)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO# 10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	1	2	1	2	2	1	1	1	1	1	1	2	1	1
CO#2	3	2	2	2	2	2	1	1	1	2	1	1	2	1	1
CO#3	3	3	3	1	1	2	1	1	2	2	1	1	3	3	2
CO#4	1	2	2	1	1	2	2	1	2	1	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE715	Low Power VLSI	PEL	3	0	0	3	3
Pre-requisites			Course Assessment methods: (Continuous Assessment (CA:15%), Mid-Term Assessment (MA:25%) and End-Term Assessment (EA:60%))				
Semiconductor Devices and Technology (ECC302), Microelectronic Circuits (ECC404), VLSI Design (ECC601)			Continuous Assessment (CA): Quizzes/Class tests/Assignments/Attendance				
Course Outcomes	**CO1: Learn** to design and optimize CMOS logic circuits and extract parasitic elements. **CO2: Understand** sources of power dissipation and be able to estimate energy dissipation in typical circuits **CO3: Apply** different techniques to minimize dynamic dissipation. **CO4: Learn** the different sources of leakage in MOS transistors and how to minimize leakage dissipation at the device level as well as in circuit design.						

Syllabus/ Topics Covered	**Module-I:**(L – 05) **Introduction**: Need for Low power VLSI chips, MOS Transistor structure and device model, The CMOS inverter and other gates; why CMOS for Low Power? CMOS Logic design methodology, Circuit optimization for performance. **Module – II:** (L – 06) **CMOS layout and Fabrication**: Typical CMOS circuit layout, IC fabrication overview, CMOS process flow, Imperfections in fabrication steps, Design rules and their importance; MOS device details – parasitic elements and their estimation, importance of device scaling. **Module – III:** (L- 06) **Power dissipation mechanisms in CMOS circuits**: Static and Dynamic dissipation, Dynamic power dissipation – switching loss, short circuit dissipation, concept of switching activity; Concept of signal activity, signal probability and activity, Signal activity computation – Boolean difference, estimation of probability and activity in complex logic circuits; **Module – IV**: (L – 08) **Dynamic dissipation management** –Supply voltage scaling approaches**:** Static Voltage Scaling; Single-level Voltage Scaling (SVS), Speed vs dissipation, Speed management approaches, circuit level – Transistor sizing, Architecture level – Parallel and pipeline architectures, Algorithm level transformations; Static Voltage Scaling Design Procedure, Critical path and its management; Multi-level Voltage Scaling (MVS), MVS issues – Layout, Level converters, Power up/down sequencing; Dynamic Voltage Scaling; Dynamic Voltage and Frequency Scaling (DVFS), DVFS architecture. **Module-V:** (L – 06) **Dynamic dissipation management – Switched capacitance minimization approaches**: What is switched capacitor? Switched capacitor minimization techniques – Hardware/Software trade-off, Bus Encoding, Use of Number system, Glitching Power minimization, Architecture Level Optimization, Clock gating, State Encoding of FSM's. **Module-VI:** (L – 06) **MOS Transistor revisited**: Review of quantum theory of solids, concept of quantum mechanical tunneling, Leakage mechanisms in MOS transistor – diode leakage, sub-threshold current, sub-threshold swing; short channel effects – Gate tunneling, reducing gate tunneling – high-k technology, DIBL and GIDL effects; Recent advances in MOS transistor design – SOI technology, FinFET, Gate All Around (GAA) FET. **Module-VII:** (L – 03) **Static Power Optimization Techniques**: Comparison of static and dynamic loss in modern chips; Stand-by and Run-time leakage; Stand-by leakage reduction techniques, Transistor stacking, VT CMOS approach, Power gating, MT CMOS technology, Power gating issues, DVFS with Power gating; Run-time leakage reduction, Dynamic V_{DD} scaling, Dual V_t approach, V_t hopping. **Module-VIII:** (L – 02) **Battery operated system design**: Battery construction and working principle, Battery capacity and energy density, comparison of different storage cell technologies; Battery charging and discharging profiles and their effects on battery capacity and life; Design of multi-battery system installations.
Text Books, and/or reference	**Text Books:** 1. Ajit Pal, **"** *Low Power VLSI Circuits and Systems***"**, Springer, 2015.

material	2. Kaushik Roy and Sharat C Prasad, **"***Low Power CMOS VLSI circuit Design***"**, John Wiley and Sons, 2000. **Reference Books:** 1. Anantha P Chandrakasan and Robert W Brodersen, **"***Low Power Digital CMOS Design***"**, Kluwer Academic Publishers, Holland, 1995. 2. Gary B Yeap K, **"***Practical Low Power Digital VLSI Design***"**, Kluwer Academic Publishers, 1998. 3. Kuo J B and Lou J H, **"***Low Voltage CMOS VLSI Circuits***"**, John Wiley and Sons, Singapore, 1999.

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	1	3	2	2	1	1	1	1	1	1	2	2	2	1
CO#2	2	3	2	1	1	1	1	1	1	1	2	1	2	2	1
CO#3	3	3	3	2	1	1	1	1	1	1	1	1	3	3	2
CO#4	3	2	3	2	1	1	1	1	1	1	1	1	3	3	2

COURSE ARTICULATION MATRIX

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE716	Advanced Antenna Synthesis	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Electromagnetic Theory and Transmission Lines (ECC403), Communication Systems I (ECC401), Communication Systems II (ECC501), Microwave and Antenna Engineering (ECC602)	CT+MT+EA

Course Outcomes	**CO 1:** Ability to characterize resonance and radiation property of an antenna based on application **CO 2:** Learn various design parameters that affects an antenna and antenna array patterns. **CO 3:** Understand different types of antenna based on the radiation mechanism like wire antenna, aperture antennas, traveling wave antenna. **CO 4:** Understand different types of antenna based on the design mechanism like log periodic antenna, log spiral antenna and electrically long antenna as well as electrically small antenna. **CO 5:** Analyze and synthesize different types of antennas for different wireless communications.
Topics Covered	**Module I. Brief review on antenna fundamentals [L – 4]** Antenna fundamentals; Vector potentials and solution of the vector potential wave equation; Antenna theorems and definitions. **Module II. Antenna Array design and characterization [L – 6]** Linear, planar and circular array - theorems and pattern synthesis. **Module III. Integral Equations [L – 4]** Moment method, self and mutual impedances

	Module IV. Scanning antennas [L – 8] Signal processing antennas, travelling wave and broadband antenna; Concept of smart antennas. **Module V. Microstrip antennas [L – 8]** Operating principle, modes, field patterns, impedance, feeding techniques and polarization; Arrays and feed networks. **Module VI.** Aperture antennas **[L – 6]** Huygen's principle, Babinet's principle; Fourier transform theory and its applications; The Geometrical theory of diffraction and uniform theory of diffraction techniques and their applications. **Module VII. Antenna measurements [L – 6]** Antenna ranges, Impedance Measurements, Radiation Patterns, Gain Measurements, Directivity Measurements, Radiation Efficiency, Current Measurements, Polarization Measurements**.**
Text Books, and/or reference material	**Text Books:** [1] C. A. Balanis, *Antenna Theory : Analysis and Design*, 3rd ed., John Wiley & Sons, Hoboken, New Jersey, 2005 [2] John D.Kraus, Ronald J.Marhefka "*Antennas: for all Applications*" 4th ed.,, Tata McGraw- Hill Inc., New Delhi, 2006. **Reference Books:** [1] E C Jordan and K G Balmain, *Electromagnetic Waves & Radiating Systems*, 2nd ed., Pearson, New Delhi, 2015 [2] R. C. Johnson and H. Jasik, "*Antenna Engineering handbook*", 3rd ed., Mc-Graw Hill Inc., New York, 1993. [3] I. J. Bhal and P. Bhartia, "Micro-strip antennas", Artech house, Dedgham, MA, 1980. **Online Reference Material(s):** https://nptel.ac.in/courses/117107035/

COURSE ARTICULATION MATRIX

Mapping CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	**Total contact hours: 42**				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE 717	mm Wave and THz Communication	PCR	3	0	0	3	3

Pre requisite: 1. Electromagnetic Theory and Transmission	Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA)):

Lines (ECE403) 2. Microelectronic Circuits (ECC404)	Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination
Course Outcomes	**CO#1:** Students will be able to learn the intricacies of mm wave and THz communication channel **CO#2:** Enriched understanding on mm wave and THz Communication devices and circuits **CO#3**: Ability to characterize microwave and mm wave and THz integrated circuits **CO#4** : Design and develop mm-wave and THz Communication devices and circuits
Topics Covered/ syllabus	**Module I [L-6]** **Introduction to mm-wave and THz Technology**: mm-Wave and THz wave Characteristics, Regulation, Propagation at mm-Waves, THz Propagation and Channel Modeling. **Module II [L-6]** **mm-wave and THz components and circuits** : mm-Wave and THz Integrated Passive Components, Circuits and Interconnects, Millimetre-wave design considerations, mm-Wave and THz component packaging. **Module III [L-6]** **mm-wave and THz Communication:** Advanced beam steering technology, Advanced beamforming technology, Advanced antenna ID technology, Millimeter- Wave MIMO: Spatial diversity of antenna arrays. **Module IV [L-8]** **THz communication**: Motivation, Differences between microwave, mmWave and THZ communication, propagation and characteristics, power consumption, multiantenna signal processing, Applications of THz **Module V [L-8]** **Channel models**: MIMO and massive MIMO channel modeling, spatial channel models, 3GPP channel models, mmWave channel models, Terahertz Channel Model. **Module VI [L-8]** **Baseband signal processing:** Channel estimation, pilot assignment, estimating direction of arrivals and departures, Signal detection techniques, hardware impairments
Text Books, and/or reference material	**Text Books:** [1] Duixian Liu, Brian Gaucher, Ulrich Pfeiffer and Janusz Grzyb, *Advanced Millimeter-wave Technologies Antennas, Packaging and Circuits*, John Wiley & Sons Ltd, United Kingdom, 2009 [2] Kao-Cheng Huang, Zhaocheng Wang, Millimeter wave communication systems, John Wiley & Sons, Inc., Hoboken, New Jersey 2011 [3] Thomas Kürner, Daniel M. Mittleman and Tadao Nagatsuma, THz Communications. Springer Series in Optical Sciences, vol 234. Springer, Cham. https://doi.org/10.1007/978 -3-030- 73738-2_1 **Reference Books:** [1] P A Rizzi, *Microwave Engineering: Passive Circuits*, 2000, PHI [2] R E Collin, *Foundations of Microwave Engineering*, John Wiley and Sons India Pvt. Ltd [3] Sorin Voinigescu, *High Frequency Integrated Circuits*, Cambridge University Press, UK, 2013

COURSE ARTICULATION MATRIX

Mapping of Course Outcome (CO) to Programme Outcome (PO) and Programme Specific Outcome (PSO)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO# 10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	1	2	1	2	2	1	1	1	1	1	1	2	1	1

CO#2	3	2	2	2	2	2	1	1	1	2	1	1	2	1	1
CO#3	3	3	3	1	1	2	1	1	2	2	1	1	3	3	2
CO#4	1	2	2	1	1	2	2	1	2	1	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECE718</td><td>DSP Architectures in VLSI</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods:
(Continuous Assessment (CA), Mid-term assessment (MA) and End term assessment (EA))</td></tr>
<tr><td colspan="3">VLSI Design (ECC601),
Digital Signal Processing (ECC402)</td><td colspan="5">CA comprises of : Assignment(s), Quiz(zes) /Class test(s)</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After the completion of the course, the student will be able to:
• CO1:State VLSI design methodology for signal processing systems.
• CO2:Describe VLSI algorithms and architectures for DSP.
• CO3:Implement/Simulate basic architectures for DSP using Matlab/CAD tools.
• CO4:Analyze DSP architectures and evaluate their performance.
• CO5:Discuss various issues that need to be addressed when implementing DSP algorithms in real hardware with finite resources such as processing speed, memory, and bit resolution.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I. Introduction to Digital Signal Processing [L – 6]
Review of DSP fundamentals: Discrete Systems: Representation of Systems, Properties of DSP systems, Difference equation and its relationship with system function, Impulse response and frequency response.
Module II. Digital Signal Processing Algorithms [L – 6]
Introduction for DSP algorithms: VLSI Design flow, Mapping algorithms into Architectures: Graphical representation of DSP algorithms – signal flow graph (SFG), data flow graph (DFG), critical path, dependence graph (DG). Data path synthesis, control structures, Optimization at Logic Level and architectural Design, Loop bound and iteration bound, Algorithms for computing iteration bound
Module III. Introduction to DSP systems [L – 5]
DSP Systems, Parallel and pipeline of signal processing application: Architecture for real-time systems, latency and throughput related issues, clocking strategy, power-aware structures, array architectures; Pipelining processing of Digital filter, Parallel processing, Parallel and pipelining for Low power design, Optimization with reference to speed, area and power, asynchronous and low power system design, ASIC (application-specific integrated circuits) and ASISP (application-specific instruction-set processors) design.
Module IV. Systolic Array Architecture [L – 6]
Methodology of systolic array architecture, FIR based Systolic Array, Selectionof Scheduling Vector, Matrix multiplication of systolic array.
Module V. Signal processing Architectures [L – 7]
Convolution technique, Retiming concept, Folding/Unfolding Transformation, Fast convolution, Cook-Toom algorithm, modified Cook-Toom algorithm. CORDIC architecture.</td></tr>
</table>

	Module VI. Scaling and Round-off noise [L – 5] Scaling and round-off noise, scaling operation, round-off noise, state variable description of digital filters, scaling and round-off noise computation, round-off noise in pipelined IIR filters. **Module VII. Low Power Design [L – 7]** Theoretical background, Scaling v/s power consumption, power analysis, Power estimation approach, Power reduction techniques.
Text Books, and/or Reference materials	**Text Book:** 1. Keshab K. Parhi, "*VLSI Digital Signal Processing Systems, Design and Implementation*", Wiley-Interscience, 1999. **Reference Book:** 1. Uwe Meyer-Baese, "*Digital Signal Processing with Field Programmable Gate Arrays*", Springer, Third Edition, 2007. **NPTEL/SWAYAM/Other Video Lectures:** 1. Prof. N. Chandrachoodan, IITM, (2019) *Mapping Signal Processing Architectures in VLSI*

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	1	3	3	1	1	1	1	1	1	1	2	2	2	1
CO#2	3	2	2	1	1	1	1	1	1	1	1	1	2	1	1
CO#3	3	2	3	1	1	1	1	1	1	1	1	1	3	2	2
CO#4	1	2	3	2	1	1	1	1	1	1	1	1	3	3	2
CO#5	2	3	2	2	1	2	2	1	1	1	1	1	2	2	2

COURSE ARTICULATION MATRIX

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE719	VLSI Testing and Verification	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous Assessment (CA:15%), Mid-Term Assessment (MA:25%) and End-Term Assessment (EA:60%))					
Digital Circuits and Systems (ECC304), VLSI Design (ECC601)		Continuous Assessment (CA): Quizzes/Class tests/Assignments/Attendance					
Course Outcomes	After successful completion of the course, the student will be able to: • **CO 1:** Extend knowledge of the requirement of fault modeling in VLSI circuits. • **CO 2:** Generate test vectors to test a circuit efficiently covering maximum faults. • **CO 3:** Demonstrate the concept of Memory testing techniques. • **CO 4:** Discuss Built-in-Self Test and its application in modern digital design. • **CO 5:** Use modern tools for testing and verification.						

Syllabus/ Topics Covered	**Module I. Introduction [L –4]** Physical faults and their modeling. Fault equivalence and dominance; fault collapsing, Fault simulation: parallel, deductive and concurrent techniques; critical path tracing. **Module II. Test generation for combinational circuits[L – 4]** Boolean difference, D-algorithm, Podem, random, etc. Exhaustive, random, and weighted test pattern generation; aliasing and its effect on fault coverage. **Module III. PLA testing[L – 4]** Cross-point fault model, test generation, easily testable designs. **Module IV. Memory testing [L – 4]** Permanent, intermittent and pattern-sensitive faults; test generation. **Module V. Delay faults and hazards [L – 6]** Test pattern generation techniques, ATPG and its different types. **Module VI. Test pattern generation for sequential circuits[L – 6]** Ad-hoc and structures techniques scan path and LSSD, boundary-scan. **Module VII. Built-in Self-Test techniques[L – 6]** LBIST and MBIST. Verification: logic level (combinational and sequential circuits), RTL-level (data path and control path). Verification of embedded systems. Use of formal techniques: decision diagrams, logic-based approaches. **Module VIII. ASIC/IP Verification[L – 4]** Direct and random testing, Error detection, and correction codes. **Module IX. Post-Silicon Validation [L – 4]** Functional test patterns development and validating, test program and test software to enable functional and tress testing of features, validation with real use case applications: OS boot and stress testing, performance validation with industry-standard benchmarks, characterization of various electrical and thermal parameters as per device specification.
Text Books, and/or reference material	**Text Book:** 1. M. L. Bushnell and V. D. Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Springer, 2nd edition, 2004. **Reference Books:** 1. A. Krstic and K-T Cheng, "*Delay Fault Testing for VLSI Circuits*", Kluwer Academic Publishers, 3rd edition, 2003. 2. N. K. Jha and S. Gupta, "*Testing of Digital Systems*", Cambridge University Press, 2nd Edition, 2003. 3. M. Abramovici, M. A. Breuer and A. D. Friedman, "*Digital Systems Testing and Testable Design*", Wiley-IEEE Press, 3rd Edition, 1994. 4. P. K. Lala, "*Fault Tolerant and Fault Testable*", Prentice-Hall, 4th Edition, 1986.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	2	2	1	1	2	1	1	1	1	1	1	3	2	2
CO#2	2	1	2	2	1	2	1	1	1	1	1	1	2	2	2
CO#3	2	1	2	2	1	2	2	1	1	1	1	1	3	3	2
CO#4	2	1	2	2	1	2	1	1	1	1	1	1	3	3	2
CO#5	2	1	2	2	1	2	1	1	1	1	1	1	3	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECE720</td><td>Machine Learning for Electronic Design Automation</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">ECC504 - Artificial Intelligence and Machine Learning
ECC304 - Digital Circuits and Systems</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After the completion of the course, the student will be able to
CO 1: Understand the fundamentals of ML and its applications in EDA
CO 2: Learn about different ML algorithms and how they can be applied to solve EDA problems.
CO 3: Gain hands-on experience with ML tools and frameworks.
CO 4: Explore case studies and current research in the field of ML for EDA.
CO 5: Develop the ability to critically analyze and evaluate the performance of ML models in the context of EDA applications.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I: Introduction to EDA and Machine Learning [L-3]
Introduction to VLSI Design, EDA Tools and Workflows, High-Level Synthesis (HLS), Logic synthesis and physical design, Basics of Machine Learning: Supervised, Unsupervised, and Reinforcement Learning
Module II: Data Preprocessing and Feature Engineering [L-3]
Data Collection and Cleaning, Handling Missing Data, Data Normalization and Standardization Feature Selection and Extraction, Feature Engineering Case Studies in EDA
Module III: Discriminative and Generative Learning for EDA [L-10]
Regression Algorithms, Linear Regression, Polynomial Regression, Applications in EDA: Predictive Modeling, Classification Algorithms: Logistic Regression, Decision Trees, Random Forests, Support Vector Machines (SVM), Deep Learning, Graph Neural Network, Generative Adversarial Network (GAN), Applications in EDA: Yield Prediction, Defect Classification, Regression model for wire resistance estimation Predicting resistance values and error analysis, Case study on: VLSI cell classification (VCC)
Module IV: Machine Learning for High-Level Synthesis [L-6]
Result prediction: Timing and resource usage prediction using Lasso, ANN, XGBoost, Max frequency, throughput, area using Ridge regression, ANN, SVM, Random Forest, prediction of Latency, Operation delay, Machine Learning for Design Space Exploration in HLS
Module V: Machine learning for Logic synthesis and physical design [L-6]
Placement and Routing Prediction, Traditional Placers Enhancement, Routing Information Prediction, Placement Decision Making, Power Deliver Network Synthesis and IR Drop Predictions, 3D Integration
Module VII: Machine Learning for Analog Design [L-4]
Circuit Topology Design Automation, Device Sizing Automation, Machine Learning for Analog Layout
Module VI: Machine Learning for Verification and Testing [L-8]
Test Set Redundancy Reduction, Test & Diagnosis Complexity Reduction for Digital Design, and Analog/RF Design</td></tr>
</table>

Text Books, and/or reference material	**Text Books:** 1. I. M. Elfadel, D. S. Boning, and X. Li, eds., 2019. Machine Learning in VLSI Computer-Aided Design, Cham: Springer. **2.** N. A. Sherwani, 2012. Algorithms for VLSI Physical Design Automation. Springer Science & Business Media. **Reference Material:** 1. A. B. Kahng, J. Lienig, I. L. Markov, and J. Hu, 2011. VLSI Physical Design: From Graph Partitioning to Timing Closure (Vol. 312). Netherlands: Springer. 2. A. Géron, 2022. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow. O'Reilly Media, Inc. "Springer Handbook of Speech Processing" (Vol. 1) edited by Jacob Benesty, M. Mohan Sondhi, and Yiteng Huang, 2008. *Berlin: Springer*.

COURSE ARTICULATION MATRIX

Mapping CO (Course Outcome)
to
PO (Programme Outcome) and PSO (Programme Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE721	Embedded Machine Learning	PEL	3	0	0	3	3
Pre-requisites		ECC503 - Microcontrollers and Embedded Systems CSC02 - Data Structure and Algorithms ECC304 - Digital Circuits and Systems					
Course Outcomes	After the completion of the course, the student will be able to **CO 1**: Explain and apply the fundamental concepts of Embedded Machine Learning **CO 2**: Proficiency in Embedded Machine Learning Tools and Frameworks **CO 3**: Ability to Collect and Preprocess Data **CO 4**: Competence in Model Optimization and Deployment **CO 5:** Development and Implementation of Embedded Machine Learning Projects						
Topics Covered	**Module I: Introduction to Embedded Systems and Machine Learning [L-4]** Introduction to embedded systems, Overview of machine learning, Applications of embedded machine learning, Embedded System Components: Microcontrollers and microprocessors, Sensors and actuators, Communication protocols and interfaces **Module II: Fundamentals of Machine Learning [L-8]** Types of machine learning: supervised, unsupervised, and reinforcement learning Key concepts: features, labels, training, and testing; Overview of common algorithms: linear regression, classification, clustering; Introduction to neural networks Convolutional Neural Networks (CNNs); Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) **Module III: Embedded Machine Learning Platforms and Tools [L-6]** Introduction to development platforms: Arduino Nano 33 BLE Sense, ESP32; Overview of TinyML and its significance, Setting up development environments, Embedded Machine Learning Frameworks: TensorFlow Lite, Edge Impulse, TFLite Micro **Module IV: Data Collection and Preprocessing [L-4]** Data Acquisition Collecting data from sensors; Data logging and storage Wireless data transmission; Data Preprocessing: Data cleaning and normalization Feature extraction and selection, Splitting data into training, validation, and test sets **Module V: Training Machine Learning Models [L-6]** Training models on desktop/laptop, Transfer learning and fine-tuning, Evaluating model performance, Optimization for Embedded Systems: Model quantization and pruning Reducing memory and computation requirements, Techniques for low-power machine learning **Module VI: Deployment on Embedded Devices [L-4]** Converting models to TensorFlow Lite format, Deploying models to microcontrollers, Real-time inference and decision-making, Concepts of edge computing Benefits of on-device inference **Module VII: Applications and Case Studies [L-8]** Case A: Motion Classification using MCU (Nano 33) Case B: K-means Clustering & Anomaly Detection Case C: Deployment of Keyword Spotting on MCU ((Nano 33)						
Text Books, and/or reference material	**Text Books:** **1.** "TinyML: Machine Learning with TensorFlow Lite on Arduino and Ultra-Low-Power Microcontrollers" by Pete Warden and Daniel Situnayake, 2019. O'Reilly Media. **Reference Material:** **1.** "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville, 2016. MIT Press. **2.** "TinyML Cookbook: Combine Artificial Intelligence and Ultra-Low-Power Embedded Devices to Make the World Smarter" by Gian Marco Iodice, 2022. Packt Publishing Ltd.						

COURSE ARTICULATION MATRIX

Mapping CO (Course Outcome)
to
PO (Programme Outcome) and PSO (Programme Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 40				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE722	Deep Learning in Signal Processing	PEL	3	0	0	3	3
Pre-requisites		ECC504 - Artificial Intelligence and Machine Learning ECC402 - Digital Signal Processing CSC02 - Data Structure and Algorithms					
Course Outcomes	After the completion of the course, the student will be able to **CO 1**: Understand the core concepts of Signal Processing Algorithms **CO 2**: Application of Deep Learning Techniques **CO 3**: Proficiency in Signal-Specific Data Handling **CO 4**: Model Optimization for Signal Processing **CO 5:** Development of Innovative Solutions for complex signal processing tasks						
Topics Covered	**Module I: Fundamentals of Signal Processing Learning [L-6]** Basics of signals and systems, Signal representation and sampling, Fourier Transform, Short-Time Fourier Transform (STFT), and Wavelet Transform, Spectral analysis and time-frequency representations, Mel-Frequency Cepstral Coefficients (MFCCs), Principal Component Analysis (PCA) for signal data **Module II: Fundamentals of Machine Learning and Deep Learning [L-10]** Types of machine learning: supervised, unsupervised, and reinforcement learning Key concepts: features, labels, training, and testing; Overview of common algorithms: linear regression, classification, clustering; Introduction to neural networks Convolutional Neural Networks (CNNs); Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM); Transformer architecture **Module III: Preprocessing and Signal Data Handling [L-6]** Signal normalization and denoising Handling missing or incomplete data, Techniques for signal data augmentation; Synthetic data generation for signal processing **Module IV: Data Collection and Preprocessing [L-4]** Data Acquisition Collecting data from sensors; Data logging and storage Wireless data transmission; Data Preprocessing: Data cleaning and normalization Feature extraction and selection, Splitting data into training, validation, and test sets **Module V: Specialized Applications in Signal Processing[L-8]**						

	Speech and Audio Processing: Speech recognition using deep learning models, Audio classification and speaker identification; Biomedical Signal Processing: ECG, EEG, and EMG signal analysis, Deep learning for health monitoring and diagnosis; Image Signal Processing: Image segmentation and enhancement, Applications in medical imaging and remote sensing **Module VI: Model Optimization and Deployment [L-6]** Model quantization, pruning, and knowledge distillation Reducing computational and memory requirements; Deployment of deep learning models on edge devices Real-time inference for signal processing applications
Text Books, and/or reference material	**Text Books:** **1.** "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville, 2016. MIT Press. **2.** "Introduction to Digital Speech Processing" by Lawrence Rabiner and Ronald Schafer, 2007. *Foundations and Trends in Signal Processing*. **Reference Material:** **1.** **"**Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" by Aurélien Géron, 2019 (2nd Edition). *O'Reilly Media*. **2.** "TinyML Cookbook: Combine Artificial Intelligence and Ultra-Low-Power Embedded Devices to Make the World Smarter" by Gian Marco Iodice, 2022. Packt Publishing Ltd.

COURSE ARTICULATION MATRIX

Mapping CO (Course Outcome)
to
PO (Programme Outcome) and PSO (Programme Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE723	MIMO Communication	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Communication Systems II (ECC501)		CT+EA					
Course Outcomes	**CO1: Understand** useful mathematical tools for MIMO communication **CO2: Learn** MIMO channel characteristics and **Analyze** capacity						

	CO3: Learn space time codings and its **Application** in MIMO communication **CO4: Understand** detectors for MIMO communication **CO5: Learn** useful application of MIMO communication
Topics Covered	**Module 1: Introduction to MIMO [6 hrs.]** Linear algebra, random variables, probability, Different antenna configurations (SISO, SIMO, MISO, MIMO) **Module 2: MIMO Channel [10 hrs.]** Wireless channel and its characterization, different fading models: small scale and large scale, Array gain, Diversity gain and Spatial multiplexing gain, Diversity Multiplexing trade-off, different combining techniques, expression of MIMO channel, MIMO channel characteristics **Module 3: Space Time Coding [9 hrs.]** Space Time Coding (STC), Alamouti scheme, Space time block codes, Space time trellis codes, higher order STBC, STBC concatenated with TCM, Choice of MIMO system design parameters. **Module 4: MIMO Detection [8 hrs.]** Maximum Likelihood detector, Linear sub-optimal detectors, Sphere decoding, Advanced MIMO detection, successive interference cancellation detection, Lattice reduction-based detector **Module 5: MIMO Applications [7 hrs.]** MIMO in Mobile Communication System, Massive MIMO, Cell-free MIMO, Multi-user MIMO: uplink and downlink
Text Books, and/or reference material	Reference Books: 1. David Tse, Pramod Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press 2004 2. Arogyaswami Paulraj, Rohit Nabar, Dhananjay Gore, 'Introduction to Space-Time Wireless Communications', Cambridge University Press, 2003 3. E.G. Larsson and P. Stoica, "Space-time block coding for Wireless communications", Cambridge University Press, 2003 4. T. S. Rappaport, "Wireless Communications: Principles and Practice", Pearson, Second Edition 5. Andrea Goldsmith, "Wireless Communication", Cambridge University Press 2005 6. Rakhesh Singh Kshetrimayum, "Fundamentals of MIMO Wireless Communications", Cambridge University Press 2017 7. Jerry R. Hampton, "Introduction to MIMO Communications", Cambridge University Press, 2014.

Mapping of CO (Course outcome) and PO (Programme Outcome) and PSO (Program Specific Outcome)

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

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

POs and PSOs	PO Description
PO#1	**Engineering knowledge**: Apply the knowledge of basic sciences, mathematics and electrical engineering fundamentals compounded with electronics and communication engineering to the solution of complex electronics engineering problems in integrated circuit design, wireless communication as well as networking, signal processing, high frequency circuit design in conjunction to embedded systems.
PO#2	**Problem analysis**: Identify, formulate, and analyze complex electronics engineering problems in integrated circuit design, wireless communication as well as networking, signal processing, high frequency circuit design in conjunction to embedded systems.
PO#3	**Design/development of solutions**: Imparting training for complex electronics engineering problems in integrated circuit design, wireless communication as well as networking, signal processing, high frequency circuit design that meet the specific needs with optimal consideration for the public health and safety, culture, society and environment.
PO#4	**Conduct investigations of complex problems**: Use research-based knowledge dissemination for analysis and synthesis as well as build the ability to interpret data in electronics engineering problems pertaining to integrated circuit design, wireless communication as well as networking, signal processing, high frequency circuit design.
PO#5	**Modern tool usage**: Use appropriate techniques, resources, and modern electronics engineering computation and simulation tools including prediction and modelling software to deal with complex electronics engineering problems with flavour of in-depth analysis.
PO#6	**The engineer and society**: To inculcate awareness to include societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional electronics engineering practices in wireless communications, microwave engineering, antenna installations, medical imaging, integrated circuit design and medium as well as high power radio transmission.
PO#7	**Environment and sustainability**: To include the regulatory bindings in wireless communication and use of radio frequencies in medical imaging to train manpower who can contribute to sustained development considering the environment.
PO#8	**Ethics**: Imbibe ethical principles and commitment to professional responsibilities and norms of the electronics engineering practices.
PO#9	**Individual and team work**: To nurture manpower who can function effectively as an individual as well as in groups to foster growth of the organization and society.
PO#10	**Communication**: Improving speaking and writing skills in electronics engineering such that the students can comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO#11	**Project management and finance**: Students will be able to understand management principles and apply these to one's own work, as a member and leader in a team, to manage projects in multidisciplinary facets.
PO#12	**Life-long learning**: Ushering the students to generate skills and interest to sustain continuous learning to increase awareness of developments so as to incorporate those in their technical skills.
PSO#1	**Analyze** Apply the acquired knowledge to understand the scientific, engineering and financial

	aspects of ECE related engineering problems.
PSO#2	**Design** Provide hardware and software solutions to ECE related engineering problems using modern tools.
PSO#3	**Improve** Work for improvement of living experience of individual but at the same being responsible to society and environment.

CO: **Course Outcomes are narrower statements that describe what students are expected to know, and be able to do at the end of each course/subject.

While the POs define the departmental outcomes, the COs are more oriented towards the subjects and are mostly defined by the faculties consulting higher authorities.

The COs are more like statements that relate to the skills, knowledge, and behaviour the students acquire as they go through a specific course within a program.

PO: **Programme Outcomes are narrow statements that describe what the students are expected to know and would be able to do upon the graduation. These relate to the skills, knowledge, and behaviour that students acquire through the programme.

**PSO: These are what the students should be able to do at the time of graduation. The PSOs are program specific. PSOs are written by the department offering the program. There usually are two to four PSOs for a department.

Program Specific Outcomes (PSOs) are decided by the head of the institution with the help of HoDs and department experts.