NATIONAL INSTITUTE OF TECHNOLOGY
ANDHRA PRADESH

RULES AND REGULATIONS

SCHEME OF INSTRUCTION AND SYLLABI

B.Tech. – Electronics and Communication Engineering

Effective from 2024-25

BTech Curriculum

Minimum number of credits for the students to attain **BTech degree is 150**, and the categories and the weightage of credits is as follows:

Credit Distribution

Category	Category Description	Credits	Percentage
BSC	Basic Science Courses (BSC)	**15**	10%
ESC	Engineering Science Courses (ESC)	**15**	10%
Professional Major Courses (PMC)	Professional Major Core Courses (PCC)	**60**	60%
	Professional Major Elective Courses (DEC)	**18**	
	Professional Major Work (PRC)	**6**	
	Semester-Long Internship (SLI)	**6**	
Open/Free Electives	Open Elective Courses (OEC) and DAC approved Free Electives (NPTEL, MOOCs, etc.)	**15**	10%
HSC Courses	Liberal Arts/Creative Arts Courses (LCA)	**6**	10%
	Sports Courses	**2**	
	NCC/Social Service	**1**	
	Yoga	**1**	
	English Communication	**2**	
	Personality Development/Life Skills	**1**	
	Introduction to Entrepreneurship	**1**	
	Introduction to Design Thinking	**1**	
	Total Credits	**150**	**100%**

1st Year	I Sem: 18 ± 2 Credits II Sem: 18 ± 2 Credits	Total = 36 credits
2nd Year	III Sem: 22 ± 2 Credits IV Sem: 22 ± 2 Credits	Total = 44 credits
3rd Year	V Sem: 22 ± 2 Credits VI Sem: 22 ± 2 Credits	Total = 44 credits
4th Year	VII Sem: 20 Credits VIII Sem: 6 Credits	Total = 26 credits

1. VIII Semester: The student will do either a semester-long internship or an additional courses/project at the institute.

<table>
<tr><td>Sem-IV</td><td>Open Elective /DAC approved Free Electives (NPTEL, MOOCs, etc.)
(3 credits)</td><td rowspan="4">Department Electives (DEC) for 18 credits</td><td></td></tr>
<tr><td>Sem-V</td><td>Open Elective /DAC approved Free Electives (NPTEL, MOOCs, etc.)
(3 credits)</td><td></td></tr>
<tr><td>Sem-VI</td><td>Open Elective /DAC approved Free Electives (NPTEL, MOOCs, etc.)
(3 credits)</td><td></td></tr>
<tr><td>Sem-VII</td><td>Open Elective /DAC approved Free Electives (NPTEL, MOOCs, etc.)
(6 credits)</td><td>Professional Major Work(PRC)</td></tr>
<tr><td>Sem-VIII</td><td></td><td colspan="2">Semester-Long Internship/Additional Project at the institute/Additional department elective courses for 6 credits
(6 Credits)</td></tr>
</table>

I Year I Semester

(17 Credits)

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code	Level
1	PH1011	Engineering Physics	2	0	0	2	BSC	1
2	MA1011	Differential and Integral Calculus	3	0	0	3	BSC	1
3	EC1011	Electronic Devices and Circuits	3	0	0	3	PCC	1
4	CS1011	Problem Solving through Computer Programming	3	0	0	3	ESC	1
5	PH1012	Engineering Physics Lab	0	0	2	1	BSC	1
6	EC1012	Electronic Devices and Circuits Laboratory	0	0	3	2	PCC	1
7	CS1012	Problem Solving through Computer Programming Laboratory	0	0	3	2	ESC	1
8	HS1022	Physical Education	0	0	2	1	HSC	1
	Total					**17**		

I Year II Semester

(19 Credits)

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code	Level
1	MA1061	Differential equations and Transform Techniques	3	0	0	3	BSC	1
2	EC1021	Signals and Systems	2	1	0	3	PCC	1
3	EC1031	Digital System Design	3	0	0	3	PCC	1
4	EE2601	Network Analysis	3	0	0	3	ESC	1
5	CS2101	Data structures and Applications	3	0	0	3	ESC	1
6	CS2102	Data structures and Applications Laboratory	0	0	2	1	ESC	1
7	HS1011	English for Engineers – I	2	0	0	2	HSC	1
8	HS1032	Health Education	0	0	2	1	HSC	1
Total						**19**		

II Year I Semester
(22 Credits)

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code	Level
1	MA2041	Matrices, Real and Complex Variables	3	0	0	3	BSC	2
2	EC1041	Engineering Electromagnetics	3	0	0	3	PCC	1
3	EC1051	Probability Theory and Random Processes	2	1	0	3	PCC	1
4	EC2011	Analog Electronic Circuits Design	3	0	0	3	PCC	2
5	EC2031	Microprocessors and Microcontrollers	3	0	0	3	PCC	2
6	CE1071	Environmental Science and Engineering	2	0	0	2	ESC	1
7	EC1032	Digital Systems Design Laboratory	0	0	3	2	PCC	1
8	EC2012	Analog Electronic Circuits Design Laboratory	0	0	3	2	PCC	2
9	HS1052	Social Service	0	0	2	1	HSC	1
Total						**22**		

II Year II Semester
(22 Credits)

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code	Level
1	MA2081	Numerical Techniques	2	0	0	2	BSC	2
2	EC2021	Digital Signal Processing	3	0	0	3	PCC	2
3	EC2051	Analog Communications	2	0	0	2	PCC	2
4	EC2061	Control Systems	2	0	0	3	PCC	2
5	EC3011	Linear Integrated Circuits and Applications	2	0	0	2	PCC	3
6	EC2022	Digital Signal Processing Laboratory	0	0	3	2	PCC	2
7	EC2032	Microprocessors and Microcontrollers Laboratory	0	0	3	2	PCC	2
8	MA2082	Computational Numerical Methods	0	0	2	1	BSC	1
9	HS2011	Personality Development	0	0	2	1	HSC	1
10	HS1042	Yoga	0	0	2	1	HSC	1

11	OEXXXX	Open Elective /DAC approved Free Electives (NPTEL, MOOCs, etc.)	3	0	0	3	OEC	2
Total						**22**		

III Year I Semester
(19 Credits)

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code	Level
1	EC2041	Transmission Lines and Antennas	3	0	0	3	PCC	2
2	EC3051	Digital Communications	3	0	0	3	PCC	3
4	ECXXXX	Dept Elective I	3	0	0	3	DEC	3
5	ECXXXX	Dept Elective II	3	0	0	3	DEC	3
6	EC2052	Communication Engineering Laboratory	0	0	3	2	PCC	3
7	EC3012	Linear Integrated Circuits and Applications Laboratory	0	0	3	2	PCC	2
8	HSXXXX	Introduction to Design Thinking	1	0	0	1	HSC	1
9	OEXXXX	Open Elective /DAC approved Free Electives (NPTEL, MOOCs, etc.)	3	0	0	3	OEC	3
10	CSXXXX	Design and Analysis of Algorithms	1	0	0	1	ESC	1
Total						**21**		

III Year II Semester
(23 Credits)

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code	Level
1	EC3031	VLSI Design	3	0	0	3	PCC	4
2	EC3041	Microwave Engineering	2	0	0	2	PCC	3
3	EC4051	Wireless Communications	2	0	0	3	PCC	4
4	ECXXXX	Dept Elective III	3	0	0	3	DEC	3
5	ECXXXX	Dept Elective IV	3	0	0	3	DEC	3
6	HSXXXX	Liberal Arts/Creative Arts Courses – I	3	0	0	3	HSC	1
7	HSXXXX	Introduction to Entrepreneurship	1	0	0	1	HSC	1

8	OEXXXX	Open Elective /DAC approved Free Electives (NPTEL, MOOCs, etc.)	3	0	0	3	OEC	3
Total						**21**		

IV Year I Semester
(22 Credits)

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code	Level
1	EC XXXX	Dept Elective V	3	0	0	3	DEC	4
2	EC XXXX	Dept Elective VI	3	0	0	3	DEC	4
3	EC3042	Microwave and Optical Communications Laboratory	0	0	3	1	PCC	3
4	EC XXXX	Professional Major Work				6	PRC	4
5	HS XXXX	Liberal Arts/Creative Arts Courses – II	3	0	0	3	HSC	2
6	OE XXXX	Open Elective /DAC approved Free Electives (NPTEL, MOOCs, etc.)	3	0	0	3	OEC	4
7	OE XXXX	Open Elective /DAC approved Free Electives (NPTEL, MOOCs, etc.)	3	0	0	3	OEC	4
Total						**22**		

IV Year II Semester
(6 Credits)

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code	Level
1	EC4024	Semester-Long Internship (SLI) /Additional Project at the institute/Additional department elective courses for 6 credits				6	SLI/PRC/DEC	4
Total						**6**		

List of Electives:

- Communications and Signal processing Stream:

  EC3111 Optimization Techniques
  EC3121 Data Networks
  EC3131 Information Theory and Coding
  EC3141 Digital Signal Processors
  EC3151 Optical Communications
  EC3161 Artificial Intelligence
  EC3171 Pattern Recognition
  EC4111 Digital Image Processing
  EC4121 Speech Processing
  EC4131 Introduction to Quantum Communications
  EC4141 Advanced Wireless Communications: 5G and Beyond
  EC4151 Neural Networks for Communications and Signal Processing
  EC4161 Satellite Communications

- Electronics Stream

  EC3211 Computer Architecture and Organization
  EC3221 Electronic Instrumentation
  EC3231 Nanoelectronics: Devices and Emerging Technologies
  EC3241 Embedded Systems Design
  EC3251 Fundamentals of Optoelectronic Devices
  EC3261 Semiconductor Device Modelling
  EC4211 Thin film Technology
  EC4221 Low Power VLSI
  EC4231 Quantum Transport in Modern Devices
  EC4241 Analog VLSI Design
  EC4251 FPGA Architectures and Applications

- RF and Microwave Stream

  EC3311 Fundamentals of Radar Signal Processing
  EC3321 Radar Engineering
  EC3331 Computational Electromagnetics
  EC3341 Array Signal Processing
  EC3351 Modern Antenna Design
  EC4311 Microwave Integrated Circuits
  EC4321 Microwave and Millimeter-Wave Imaging

List of Open Electives

- EC3911 Introduction to Communication Technologies
- EC3921 Elements of Statistical Learning
- EC3931 Introduction to Embedded Systems
- EC4911 Introduction to Quantum Communication
- EC4921 Thin film Deposition Techniques and Applications

VISION

To nurture and produce highly competent engineers, scientists and entrepreneurs committed towards catering to futuristic societal challenges through holistic education synergetic with innovations and vibrant research eco-system.

MISSION

- To implement best practices in teaching-learning methodologies for establishing dynamic knowledge-connected society.
- To create a conducive environment for carrying out research in multi-disciplinary areas and thereby nurturing novel thinking capabilities.
- To strengthen industry-institute interface to inculcate entrepreneurship abilities.
- To address all technological needs of the Nation for self-sustenance.

Vision of the Department of ECE:

To be recognized as a centre of academic and research excellence in the field of Electronics and Communication Engineering that endeavours to create globally competent, innovative Engineers with entrepreneurial skills, capable of addressing the industry and societal demands.

Mission of the Department of ECE:

- **M1**. To adopt a teaching-learning process that imparts technical skills and state-of-the-art knowledge with a well-blended and balanced mix of theory and practice. To provide conductive environment for the students to become technically competent in the upfront technologies of Electronics and Communications.
- **M2**. To inspire students and teachers towards innovative and collaborative research leading to the establishment of centers of excellence.
- **M3.** To stimulate the stakeholders of the department towards the entrepreneurial activity.
- **M4.** Inculcate human values and professional ethics to students and faculty members and make them philosophical towards the societal issues.

Programme Educational Objectives (PEOs) for the B.Tech. (ECE) Programme:

Within few years after the end of the B.Tech. in Electronics and Communication Engineering programme, graduates will be able to:

PEO1	Gain good foundations in the field of Electronics and Communications and make abreast of the knowledge in handling real-world challenges that mankind faces in this field.
PEO2	Enhances the skills by self-learn and research by establishing, representing and analysing the problem
PEO3	Architect the modern technological world by enhancing the skillset in the Electronics and Communications related fields and exhibiting it in more effective and efficient way.

Programme Articulation Matrix (PEO vs. Mission) for the B.Tech. (ECE) Programme:

PEO\Mission	M1	M2	M3	M4
PEO1	S	M	S	S
PEO2	S	S	M	M
PEO3	M	S	S	S

- S: Strong correlation, M: Medium correlation, L: Low correlation

Programme Outcomes (POs) for the B.Tech. (ECE) Programme:

At the end of any B.Tech. program in NIT Andhra Pradesh, graduates will be able to:

PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning**: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Specific Outcomes (PSO) for the B.Tech. (ECE) Programme:

At the end of the B.Tech. in Electronics and Communication Engineering programme, graduates will be able to:

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

I Year I Semester (17 Credits)

PH1011	Engineering Physics	BSC	3-0-0	3 Credits

Pre-Requisites: None

Detailed Syllabus:

UNIT- I WAVE OPTICS (7)

Interference: Superposition principle, coherence of light, methods to produce coherent light: division of amplitude and wavefront, Young's double slit and Newton's rings experiment: concept, working principle, and applications.

Diffraction: Introduction to Fresnel and Fraunhofer diffraction, Fraunhofer's single-slit diffraction, double-slit diffraction and diffraction grating (quantitative), and resolving power of a grating.

Polarization: Introduction to polarization, Types of polarization, Methods to produce polarization: Reflection, refraction, scattering, selective absorption and double refraction.

UNIT - II LASERS (5)

Basic theory of LASER, Einstein's coefficients and their relations, concept of population inversion, components of lasers, three and four level lasing systems, construction and working principle of various types of lasers: Nd-YAG, Helium-Neon and semiconductor lasers and their applications.

UNIT - III QUANTUM PHYSICS (7)

Origin of quantum theory and related experiments: Black-Body radiation and photo-electric effect. Heisenberg's uncertainty principle, de- Broglie's wave concept, wave function, and its properties, operators, Schrödinger's time-dependent and time-independent equations (Quantitative), particle in one-dimensional, infinite potential well, quantum tunnelling phenomena and their applications in alpha decay, and scanning tunnelling microscopy (STM). Introduction to Quantum Technology (Q-switching, interaction of radiation with matter).

UNIT - IV PHOTOVOLTAICS (4)

Introduction to semiconductors, Solar spectrum, photovoltaic (PV) effect, materials, structure and working principle, I-V characteristics, power conversion efficiency, quantum efficiency, emerging PV technologies, and applications.

UNIT - V MAGNETIC AND NANO MATERIALS (5)

Magnetic Materials:

Introduction to Weiss theory of ferromagnetism, concepts of magnetic domains, spontaneous magnetization, Curie transition, hard and soft magnetic materials and their applications.

Nanomaterials:

Introduction, classification, and properties of nanomaterials, various methods of synthesizing nanomaterials: top-down (ball milling) and bottom-up (sol-gel) approaches.

Textbooks:

1. M. N. Avadhanulu, P. G. Kshirsagar, A Textbook of Engineering Physics, Revised Edition, S. Chand and Company (2014).
2. Beiser A., Concepts of Modern Physics, 7th Edition, Mc. Graw Hill Publishers (2017).
3. Ajoy Ghatak, Optics, 7th Edition, Tata Mc Graw Hill (2020).
4. Ajoy Ghatak and K. Thyagarajan, Lasers- Fundamentals and Applications, 2nd Edition, Laxmi Publications (2019).

Reference Books:

1. William D. Callister, Materials Science and Engineering: An Introduction (Tenth edition), John Wiley & Sons (2018).
2. Charles Kittel, Introduction to Solid State Physics, 8th Edition, Wiley Publishers (2012).

MA1011	**Differential and Integral Calculus** I B.Tech. I Semester - BT, CE, CSE, ECE, EE, MME, MECH	**BSC**	**3-0-0**	**3 Credits**

Pre-requisites: None

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

CO 1	Understand the concepts of limit, continuity and differentiability.
CO 2	Understand the concepts of partial derivative, chain rule and total differentiation.
CO 3	Find the maxima and minima of multivariable functions.
CO 4	Analyze improper integrals and evaluate multiple integrals in various coordinate systems
CO 5	Apply the concepts of gradient, divergence and curl to formulate engineering problems.
CO 6	Convert line integrals into area integrals and surface integrals into volume integrals.

Differential Calculus of functions of several variables: Review of Limit, continuity (sequential verification) and differentiability, Partial differentiation; Total differentiation; Euler's theorem and generalization; Change of variables- Jacobians; Maxima and minima of functions of several variables (2 and 3 variables); Lagrange's method of multipliers. (14)

Integral Calculus: Convergence of improper integrals; Beta and Gamma integrals; Differentiation under integral sign; Double and Triple integrals - computation of surface areas and volumes; change of variables in double and triple integrals. (14)

Vector Calculus: Scalar and vector fields; vector differentiation; level surfaces; directional derivative; gradient of a scalar field; divergence and curl of a vector field; Laplacian; Line and Surface integrals; Green's theorem in a plane; Stokes' theorem; Gauss Divergence theorem. (14)

Textbooks:

1. Joel R. Hass, Maurice D. Weir, George B. Thomas, Thomas' Calculus, 12th

edition, Pearson , 2010.
2. Erwin Kreyszig, Advanced Engineering Mathematics, Eighth Edition, John Wiley and Sons, 2015
3. B. S. Grewal, Higher Engineering Mathematics, Khanna Publications, 2015
4. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Fifth Edition, Narosa Publishing House, 2016.
5. T. M. Apostol, Calculus, Volumes 1 and 2 (2nd Edition), Wiley Eastern, 1980.

EC1011	**Electronic Devices and Circuits**	**PCC**	**3–0–0**	**3 Credits**

Prerequisites: None

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

CO1	Understand the characteristics and applications of semiconductor diodes, Zener diodes, and negative resistance devices.
CO2	Analyze the characteristics and configurations of BJTs.
CO3	Evaluate different transistor biasing techniques
CO4	Explain the working and biasing of FETs in various modes of operation.
CO5	Analyze small-signal amplifiers using BJTs and FETs.

Detailed Syllabus:

SEMICONDUCTOR DIODES: Band structure of PN junction, current components, Quantitative theory of PN diode, Volt-ampere characteristics and its temperature dependence, Narrow-base diode, Transition and diffusion capacitance of p-n junction diodes, Breakdown of junctions on reverse bias, Rectifiers, Clipper and Clampers, Zener and Avalanche breakdowns, Zener diode as voltage regulator. Negative Resistance Devices: Concept of voltage and current-controlled negative resistance, Tunnel diode: construction, V-I characteristics, applications. Unijunction transistor: operation and applications.

JUNCTION TRANSISTOR: PNP and NPN junction transistors, Characteristics of the current flow across the base regions, Minority and majority carrier profiles, Transistor as a device in CB, CE and CC configurations, and their characteristics, Ebers-Moll Model of BJT.

TRANSISTOR BIASING: The operating Point, DC & AC load lines, Fixed Bias and problems, Collector Feedback Bias, Emitter Feed Back Bias, Self-Bias and problems, Stabilization, various stabilization circuits, Thermal runaway and thermal stability.

FIELD EFFECT TRANSISTORS: JFET and its characteristics, pinch off voltage and drain saturation current, MOSFET: enhancement, depletion modes, Biasing of FETs.

SMALL SIGNAL LOW FREQUENCY TRANSISTOR AMPLIFIER CIRCUITS: Transistor hybrid model, Analysis of transistor amplifier circuits using 'h' parameters, Conversion formulae for the parameters of the three configurations, Analysis of single stage transistor amplifier circuits, RC coupled amplifier. Effect of bypass and coupling capacitors on the low frequency response of the amplifier, FET amplifier configurations, Low frequency response of amplifier circuits, Analysis of single stage FET amplifier circuits.

Textbooks:

1. Millman and Halkias, Integrated Electronics, 2nd Edition, Tata McGraw Hill, 2010.
2. David A. Bell, Solid State Pulse Circuits, 4th Edition, Prentice Hall India, 2009.
3. Robert L Boylested and Louis Nashelsky, Electronic Devices and Circuit Theory, 8^{th} Edition, PHI, 2003
4. Y.N. Bapat, Electronic devices and circuits, Discrete and Integrated, 3rd Edition, Tata McGraw Hill, 2011.
5. Millman and Taub, Pulse, Digital and Switching Waveforms, 3rd Edition, Tata McGraw Hill Education, 2011.

CS1011	**Problem Solving through Computer Programming**	**ESC**	**3 – 0 – 0**	**3 Credits**

Pre-requisites: None

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

CO1	Construct algorithms for solving problems that requires solutions involving searching, sorting, selection and / or a numerical method as a sub-routine.
CO2	Analyze the suitability of different algorithmic design paradigms for solving problems with an understanding of the time and space complexities incurred.
CO3	Construct algorithms for solving problems with an understanding of the internals of a computing system and its components like processor, memory and I/O sub-systems.
CO4	Construct efficient modular programs for implementing algorithms by leveraging suitable control structures.
CO5	Construct efficient programs by selecting and using suitable in-built Data Structures and programming language features available.

Detailed Syllabus:

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

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

Number systems and data representation, Basic data types. Numbers, Digit separation, Reverse order, writing in words, Development of Elementary School Arithmetic Testing System, Problems on Date and factorials, Solutions using flow of control constructs, Conditional statements - If-else, Switch case constructs, Loops - while, do-while, for.

Functions – Modular approach for solving real time problems, user defined functions, library functions, parameter passing - call by value, call by reference, return values, Recursion, Introduction to pointers.

Sorting and searching algorithms, Large integer arithmetic, Single and Multi-Dimensional Arrays, passing arrays as parameters to functions

Magic square and matrix operations using Pointers and Dynamic Arrays, Multidimensional Dynamic Arrays

String processing, File operations

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

Textbooks:

1. R.G. Dromey, How to solve it by Computer, Pearson, 2008.
2. Brian W.Kernighan, Dennis Ritchie, The C Programming Language, 2nd edition, Person Education India, 2015
3. Walter Savitch, Problem Solving with C++, Ninth Edition, Pearson, 2014.
4. Cay Horstmann, Timothy Budd, Big C++, 2nd Edition, Wiley, 2009.

List of experiments:

1. Determination of radius of curvature of plano-convex lens using Newton's ring experiment.
2. Determination of the width of narrow-slit by diffraction method
3. Determination of wavelength of spectral lines of Mercury light by normal incidence method using diffraction grating
4. Determination of Planck's constant using light emitting diode
5. Study the B-H loop hysteresis and find the coercivity and retentivity of magnetic materials
6. To study the current-voltage characteristics of a photovoltaic material using solar cell
7. Determination of wavelength of diode laser using diffraction by metal scale
8. Determination of dielectric constant of various dielectric materials
9. Determination of numerical aperture of an Optical fibre
10. Estimation of specific rotation of an optically active material-using Laurent's half-shade polarimeter

PH1012	**Engineering Physics Laboratory**	**BSC**	**0 – 0 – 2**	**1 Credit**

References:

1. Physics Laboratory Manual, 2024, Department of Physics, School of Sciences, National Institute of Technology Andhra Pradesh, Tadepalligudem.
2. Shukla R K, Srivastava A, 2011, Practical Physics, New Age International Pvt. Ltd., New Delhi.
3. Arora, CL, 2012, B.Sc. Practical Physics, S Chand and Company Ltd., New Delhi.
4. M. N. Avadhanulu, P. G. Kshirsagar, A Textbook of Engineering Physics, S. Chand and Company (2015).
5. R. S. Sirohi, A Course of Experiments with He-Ne Lasers, New Age International (P) Ltd. (2009)

EC1012	Electronic Devices and Circuits Laboratory	PCC	0-0-3	2 Credits

Prerequisites: None

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

CO1	Use electronic instruments to measure and analyze circuit behaviour.
CO2	Demonstrate the V-I characteristics and applications of PN junction and Zener diodes.
CO3	Construct and analyze rectifier, clipper, and clamper circuits.
CO4	Examine the characteristics, biasing, and amplifier behaviour of BJT and FET devices.

Test and verify the following experiments using hardware components in the circuits laboratory.

List of experiments:

1. Study the different active and passive elements and measuring instruments used in circuits laboratory.
2. Verification of forward and reverse bias V-I Characteristics and calculate static and dynamic resistance:
    i. PN Junction diode.
    ii. Zener diode.
3. Determination % regulation (Line and Load regulation):
    i. Zener diode.
4. Determination of ripple factor and %regulation:
    i. Half Wave Rectifier.
    ii. Full Wave Rectifier (Using Centre-Taped transformer).
5. Design and verify the response of wave shaping networks using PN junction diodes:
    i. Positive Clippers (Series and shunt).
    ii. Negative Clippers (Series and shunt).
    iii. Positive Clampers (Series and shunt).
    iv. Negative Clampers (Series and shunt).
6. Determination of h-parameters from input and output characteristics:
    i. Bipolar junction transistor (BJT).

7. Verify the output and transfer characteristics:
    i. Junction Field Effect Transistor (JFET).
8. Design of biasing network and calculation of Q-point
    i. Transistor biasing using self-bias technique
9. Design of biasing network and calculation of Q-point
    i. Junction Field Effect Transistor (JFET).
10. Plot the frequency response curve and determination of voltage, current gain, input and output impedance.
    i. BJT Common emitter Amplifier
11. Introduction to soldering, circuit design and PCB prototype implementation of any electronics circuit for real time applications.

Textbooks:

1. Millman and Halkias, Integrated Electronics, 2nd Edition, Tata McGraw Hill, 2010.
2. David A. Bell, Solid State Pulse Circuits, 4th Edition, Prentice Hall India, 2009.
3. Robert L Boylested and Louis Nashelsky, Electronic Devices and Circuit Theory, 8th Edition, PHI, 2003
4. Y.N. Bapat, Electronic devices and circuits, Discrete and Integrated, 3rd Edition, Tata McGraw Hill, 2011.

CS1012	**Problem Solving through Computer Programming lab**	**ESC**	**0 –0 – 3**	**2 Credits**

Pre-requisites: None

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

CO1	Construct, debug, test and run efficient programs by leveraging suitable flow of control constructs and syntactic units of the programming language.
CO2	Construct efficient programs by constructing and translating algorithms for solving problems using sorting, searching, selection and / or arithmetic computations.
CO3	Implement, refactor, test and debug functional programs in a shell-based run time environment.
CO4	Construct efficient programs by demonstrating problem-solving skills and outof-the-box algorithmic thinking.

Detailed Syllabus:

List of Experiments:

1. Familiarization with basic shell commands, execution of and debugging programs in Linux environment
2. Programs on conditional control constructs.
3. Programs on iterative constructs. (while, do-while, for).
4. Programs using user defined functions and in-built function calls
5. Programs related to Recursion.
6. Programs on single and multi-dimensional arrays
7. Programs related to String processing
8. Programs related to Pointers
9. Programs on Structures and Unions
10. Programs related to Files and I/O.

Textbooks:

1. R.G. Dromey, How to solve it by Computer, Pearson, 2008.
2. Brian W.Kernighan, Dennis Ritchie, The C Programming Language, 2nd edition, Person Education India, 2015
3. Walter Savitch, Problem Solving with C++, Ninth Edition, Pearson, 2014.
4. Cay Horstmann, Timothy Budd, Big C++, 2nd Edition, Wiley, 2009.

I Year II Semester (19 Credits)

MA1061	Differential Equations and Transform Techniques	BSC	3 - 0 - 0	3 Credits

Prerequisite: Differential and Integral Calculus (MA1011)

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

CO1	determine the solution of a PDE by variable separable method
CO2	understand the concepts of Fourier series and Fourier transform
CO3	solve arbitrary order linear differential equations with constant coefficients
CO4	apply Laplace transforms to solve physical problems arising in engineering

Ordinary Differential Equations of Higher Order: Higher order linear differential equations with constant coefficients - homogeneous and non-homogeneous; Euler and Cauchy's differential equations; Method of variation of parameters; System of linear differential equations; applications in physical problems. (16)

Laplace Transforms: Laplace transforms; inverse Laplace transforms; Properties of Laplace transforms; Laplace transforms of unit step function, impulse function, periodic function; Convolution theorem, Solving certain initial value problems, Solving system of linear differential equations, Finding responses of systems to various inputs viz. sinusoidal inputs acting over a time interval, rectangular waves, impulses etc. (14)

Fourier Transforms: Expansion of a function in Fourier series for a given range, Half range sine and cosine expansions Fourier transformation and inverse transforms, sine, cosine transformations and inverse transforms, simple illustrations. (12)

Textbooks:

1. R.K.Jain and S.R.K.Iyengar, Advanced Engineering Mathematics, Narosa Pub. House,Fifth edtion, 2016.
2. Erwyn Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8^{th} Edition, 2008.
3. B.S.Grewal, Higher Engineering Mathematics, Khanna Publications, 44th edition, 2017.
4. T. M. Apostol, Calculus, Volume 2 (2nd Edition), Wiley Eastern, 1980.
5. G. F. Simmons, Differential equations with applications and historical notes. CRC Press, 2016.

EC1021	Signals and Systems	PCC	3–0–0	3 Credits

Prerequisites: None

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

CO1	Classify the signals as Continuous time and Discrete time
CO2	Analyze the spectral characteristics of signals using Fourier analysis
CO3	Classify systems based on their properties and determine the response of LTI system using convolution.
CO4	Identify system properties based on impulse response and Fourier analysis
CO5	Apply transform techniques to analyze continuous-time and discrete-time signals and systems

Detailed Syllabus:

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

LINEAR TIME INVARIANT SYSTEMS: Discrete Time LTI Systems, Continuous Time LTI Systems, impulse response and step response of LTI systems, properties of LTI Systems, causal LTI Systems Described by Difference equations.

FOURIER SERIES REPRESENTATION OF PERIODIC SIGNALS: Response of LTI systems to Complex Exponentials, Fourier series Representation of CT periodic Signals, properties of CT Fourier Series, Fourier Series representation of DT periodic Signals, properties of DFS, Fourier series and LTI Systems, Filtering, Examples of CT filters, Examples of DT filters.

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

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

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

SAMPLING: Sampling theorem, Impulse sampling, sampling with zero order Hold, Reconstruction of signal from its samples using interpolation, Effect of under sampling.

LAPLACE TRANSFORMS: Review of Laplace transforms, Inverse Laplace transform, Concept of region of convergence (ROC) for Laplace transforms, Properties of Laplace Transforms. relation between Laplace and Fourier transforms.

Z-TRANSFORM: Z-transform, Region of convergence and its properties, Inverse Z-transform, properties of ZT, Analysis and characterization of LTI systems using ZT, LTI Systems, System function algebra and block diagram representations. Relation among various transforms.

Textbooks:

1. Alan V. Oppenheim, Alan S. Willsky, S. Hamid Nawab, Signals and Systems, Prentice Hall India, 2nd Edition, 2024.
2. B.P Lathi, Linear Systems and Signals, 2nd edition Oxford University, 2008.
3. Micheal J Roberts, Fundamentals of Signals and Systems, Special Indian edition, Tata Mc Graw hill, 2010.
4. Simon Haykin, Barry Van Veen, Signals and Systems, Wiley, 2nd Edition, 2017.

EC1031	Digital Systems Design	PCC	3–0–0	3 Credits

Prerequisites: None

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

CO1	Explain number systems, Boolean algebra, and function minimization techniques.
CO2	Design and analyze combinational logic circuits and develop HDL models for implementation.
CO3	Understand sequential circuits, flip-flops, and counters, and develop HDL models for implementation.
CO4	Design digital systems using FSM and develop HDL models for implementation.
CO5	Explain memory types, programmable logic devices, and logic families.

Detailed Syllabus:

Number systems and Boolean algebra: Introduction to number systems and Boolean algebra; Boolean identities, basic logic functions, Canonical and standard forms of logic expressions, Product of Sums and Sum of Products Simplification minimization of Boolean functions using Karnaugh map, Quine Mc-Cluskey methods.

Combinational logic: Arithmetic circuits (Binary adder, Subtractor, Decimal adder, parallel adders, ripple-carry adder, carry- look ahead adder), decoders, encoders, multiplexers, de-multiplexers, comparator, parity checker and generator, Introduction to Verilog HDL, HDL description of combinational circuits.

Sequential logic circuits: Latches and Flip Flops (SR, JK, D, T), conversion of Flip Flop, Master slave JK flip flop; Shift register; Counters – synchronous, asynchronous; Sequential circuit design examples in Verilog HDL and simulation.
Finite state machines: Basic concepts and design; Moore and Mealy machines examples; State minimization/reduction, state assignment; Sequence detector; Finite state machine design in Verilog HDL;
Memory: Types of ROM and RAM (SRAM, DRAM, SDRAM, DDR, DDR2, DDR4); Programmable Logic Devices – PLA, PAL, CPLD, and FPGA.
Logic families: Brief overview of Transistor as a switch; Logic gate characteristics – propagation delay, speed, noise margin, fan-out and power dissipation; Overview and comparison of logic families: RTL, DTL, TTL, ECL and CMOS.

Text Books:

1. M. Morris Mano and Michael D. Ciletti, Digital Design: With an Introduction to the Verilog HDL and System Verilog, 2018, 6^{th} Edition, Pearson Pvt. Ltd.
2. Charles. H. Roth, Jr., Fundamentals of Logic Design. Fifth Edition, Thomson Brooks, 2005.
3. S. Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis. second edition, Prentice Hall, 2003.
4. John L. Hennessy David A. Patterson, Computer Organization and Design: The Hardware/Software Interface. 4th Edition, Morgan Kaufmann, 2011.
5. S. Brown and Z. Vranesic, Fundamentals of digital logic with Verilog design. Third Edition, McGraw-Hill, 2013.
6. J.F. Wakerly, Digital Design: Principles and Practices. Fourth Edition, Prentice Hall, 2005.

EE2601	**Network Analysis**	**ESC**	**3–0–0**	**3 Credits**

Prerequisites: None

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

CO1	Solve network problems using mesh current and node voltage equations
CO2	Time domain analysis of RL, RC circuits with various excitation
CO3	Steady State analysis of circuits, Phasor approach, resonance conditions of RLC circuits, Laplace transform approach
CO4	Analyze networks using Thevenin, Norton, Maximum power transfer, Superposition, Miller and Tellegen’s theorems.
CO5	Understanding of two port parameters.

Circuit Elements and Relations: Types of circuit components, Types of Sources and Source Transformations, KVL and KCL with dependent and independent Sources, Power balance relations, DC circuit analysis, Formation of loop and node equations.

Transient Analysis: Inductance circuits: Initial condition, energy storage, RL circuit analysis with DC excitation, discharging energy from inductor circuits, Capacitance circuits: Initial condition, energy storage, RC circuit analysis with DC excitation, discharging energy from capacitator circuits, General method of solving linear differential equation for RL, RC circuits with DC excitation, sinusoidal excitation and exponential excitation.

Steady State Analysis of Circuits for Sinusoidal Excitations: Concept of phasor, circuit analysis in phasor domain, Phasor diagrams, Concept of Real power, reactive power, complex power, power factor, Resonance- Series and Parallel resonance, Bandwidth, Q-factor and selectivity, solution of network equations using Laplace transform.

Network Theorems: Nortons, Thevenin's Star-delta transformation, Telligen's theorem, Reciprocity, Maximum Power transfer theorem.

Linear 2-port network parameters: Z parameters, Y parameters, H parameters, ABCD Parameters.

Textbooks:

1. William H. Hayt, Jack Kemmerly, Steven M. Durbin, Engineering Circuit Analysis, Tata McGraw- Hill, 2013, 8th Edition
2. Charles K. Alexander and Matthew. N. O. Sadik, Fundamentals of Electric Circuits, Tata McGraw Hill, 2013 7th Edition
3. M.E. Van Valken Burg, Network Analysis, PHI, 2015, 3rd edition.
4. Edward Hughes, Electrical Technology, ELBS, 2001, 6th Edition.
5. Vincent Del Toro, Electrical Engineering Fundamentals, Pearson Education India, 2015, 2nd Edition.
6. V N Mittle, A Mittal, Basic Electrical Engineering, Tata McGraw Hill, 2005, 2nd Edition.
7. RA DeCarlo & Pen-Min Lin, Linear circuit Analysis, Oxford University Press, 2003, 2nd Edition.

Online resources:

1. https://archive.nptel.ac.in/courses/108/105/108105159/
2. https://nptel.ac.in/courses/108/104/108104139/
3. https://nptel.ac.in/courses/108/102/108102097/

CS2101	**Data Structures and Applications**	**ESC**	**3 – 0 – 0**	**3 Credits**

Pre-requisites:

Problem Solving through Computer Programming (CS1011)

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

CO1	Construct Abstract Data Types for modelling entities using appropriate data constructs and methods. (Apply)
CO2	Construct list-based data structures namely Stacks, Queues, Circular Queues and Linked Lists. (Apply)
CO3	Construct non-linear data structures namely Trees & graphs and set-based structures like disjoint sets. (Apply)
CO4	Construct suitable data structures and algorithms to facilitate searching, sorting and selection. (Apply)
CO5	Construct efficient algorithms for performing operations on data structures within a given time and /or space complexity. (Apply)
CO6	Assess the suitability of various data structures for solving a given problem with a comprehension of trade-offs in time and space complexities. (Analyze)

Detailed Syllabus:
Introduction to Data Structures, Algorithm Analysis and Examples based on Asymptotic Notations, Abstract Data Types (ADTs), Stacks, Queues, Circular Queues and Linked List (Singly Linked, Doubly Linked and Circular). Applications of Stacks, Queues and Linked Lists.

Trees: Representation of Trees, Binary Trees, Binary Search Trees, Applications of Trees.

Priority Queues, Binary Heap and applications

Hash Tables and Operations, Collision Resolution: Open Addressing and Chaining.
Applications of Hash Tables.

Graphs: Representation of Graphs, Graph Traversal Techniques, Minimum Cost Spanning Trees: Prim's and Kruskal's Algorithms, Shortest Path Algorithms: Dijkstra's Algorithm and Floyd-Warshall Algorithm. Applications of Graphs.

Sorting Algorithms: Merge Sort, Heap Sort, Quick Sort and Counting Sort.

Textbooks:

1. Michael T. Goodrich, R. Tamassia, and Mount, Data Structures and Algorithms in C++, Second Edition, John Wiley and Sons, 2011.
2. Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, Fourth Edition, Pearson Education. Ltd., 2014.
3. Adam Drozdek, Thomson, Data structures and algorithms in C++, Fourth Edition, Cengage, 2013.
4. Richard F. Gilberg, Behrouz A. Forouzan, Data Structures: A Pseudocode Approach with C++, Second Edition, Thomson Learning, 2004.
5. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, Introduction to Algorithms, Third Edition, PHI, 2009.

CS2102	**Data Structures and Applications lab**	**ESC**	**0 – 0 – 2**	**1 Credit**

Pre-requisites:

i. Problem Solving through Computer Programming (CS1011)
ii. Problem Solving through Computer Programming Lab (CS1012)

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

CO1	Construct solutions for problems using linear data structures such as Linked List, Stacks and Queues. (Apply)
CO2	Construct solutions for problems using non-linear Data Structures such as Trees and Graphs. (Apply)
CO3	Implement solutions for problems that requires sorting and searching as a sub-routine. (Apply)
CO4	Analyze, evaluate and choose appropriate data structures and algorithms for a specific application. (Analyze)
CO5	Analyze algorithms with respect to their time and space complexities. (Analyze)

List of Experiments:

1. Implementation of Stacks and Queues using arrays.
2. Implementation of Stack and Queue based applications.
3. Implementation of Single Linked List, Double Linked List and Circular Linked List.
4. Implementation of Stacks and Queues using Linked List.
5. Implementation of Circular Queues.
6. Implementation of Binary Search Trees with its operations.
7. Implementation of Priority Queues.
8. Implementation of Hashing with open addressing and separate chaining methods.
9. Implementation of Graph Traversal techniques: BFS and DFS.
10. Implementation of Minimum cost spanning tree algorithms.
11. Implementation of Dijkstra and Floyd-Warshall Algorithms.
12. Implement the following sorting algorithms: Merge sort, Heap sort, Quick sort, Counting sort.

13. Mini project

Textbooks:

1. Mark Allen Weiss, Data structures and Algorithm Analysis in C++, Pearson Education. Ltd., Fourth Edition, 2014.
2. Adam Drozdek, Thomson, Cengage, Data structures and algorithms in C++, 4th Edition, 2012.
3. Michael T. Goodrich, R. Tamassia, and Mount, Data structures and Algorithms in C++, Second Edition, Wiley, 2011.
4. Richard F. Gilberg, Behrouz A. Forouzan, Data Structures: A Pseudocode Approach with C++, Pacific Grove, CA: Brooks/Cole, 2001.

II Year I Semester (22 Credits)

MA2041	Matrices, Real, and Complex Variables (II B.Tech. I Semester ECE)	BSC	3 - 0 - 0	3 Credits

Prerequisite: Differential and Integral Calculus (MA1011)
Real Sequences and Differential Equations (MA1081)

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

CO1	solve the consistent system of linear equations
CO2	apply orthogonal transformations to a quadratic form
CO3	understand the concepts of differential and integral calculus related to the function of complex variables
CO4	apply residue theory in evaluating real integrals

Matrix theory: Linear dependence and independence of vectors; Rank of a matrix; Consistency of the system of linear equations; Eigenvalues and eigenvectors of a matrix; Caley-Hamilton theorem and its applications; Reduction to diagonal form; Reduction of a quadratic form to canonical form - orthogonal transformation; Properties of complex matrices - Hermitian, skew-Hermitian and Unitary matrices.
(12)

Sequence and Series: Sequence of real numbers, Cauchy sequences, Definitions of convergence and divergence of sequences, monotone convergence theorem, Series, Tests for convergence: Ratio test, Integral test, Root test, comparison test, absolute convergent series, Power series, Radius of convergence, Taylor's series.
(14)

Complex analysis: Complex Variables: Analytic function, Cauchy Riemann equations , Harmonic function, Conjugate functions - complex integration, line integral in complex plane, Cauchy's theorem (simple proof only), Cauchy's integral formula, Taylor's and Laurent's series expansion, zeros and singularities, Residue, residue theorem, use of residue theorem to evaluate the real integrals without pole on the real axis, Schwartz-Christoffel transformation. (16)

Textbooks:

1. T. M. Apostol, Calculus, Volume 1, 2nd Edition, Wiley Eastern, 1980.
2. R.K.Jain and S.R.K.Iyengar, Advanced Engineering Mathematics, Narosa Pub. House, Fifth edtion, 2016.
3. Erwyn Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8^{th} Edition, 2008.

4. B.S.Grewal, Higher Engineering Mathematics, Khanna Publications, 44th edition, 2017.
5. Brown and Churchill, Complex Variables and Applications, McGraw-Hill and Higher Education, 9th Edition.

Reference Books:

6. Joel R. Hass, Maurice D. Weir, George B. Thomas, Thomas' Calculus, 12th edition, Pearson , 2010.
7. G. Strang, Linear Algebra and Its Applications, 4th Edition, Brooks/Cole India, 2006.
8. S. Ponnusamy, Foundations of Complex Analysis, Alpha Science International Publishers, UK, 2005.
9. A. R. Rao & P. Bhimasankaram, Linear algebra (Vol. 19). Springer, 2000.

EC 1041	Engineering Electromagnetics	PCC	3-0-0	3 Credits

Pre-Requisites: **None**

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

CO-1	Apply knowledge of vector calculus to describe Electric and Magnetic fields.
CO-2	Identify simplifying principles like symmetry to compute Electric and Magnetic fields.
CO-3	Formulate and solve problems involving time dependent electromagnetic fields using Maxwell’s equations.
CO-4	Analyze propagation of electromagnetic waves in vacuum and dielectric media.
CO-5	Understand the power flow of plane electromagnetic wave.

Syllabus:

Static Electric Field: Introduction to Coordinate Systems and Transformation, Vector Calculus, Electric field – Charge density: Line, surface and volume, Coulomb’s law, Divergence and curl of electric field, Gauss’ law, Potential, Gradient of the potential, Poisson and Laplace equation, Electrostatic work and energy, Conductors and electric fields, Field and potential of dipoles, Electric polarization vector, Gauss’ law for a dielectric medium, Electrostatic boundary conditions.

STATIC MAGNETIC FIELD: Electric current, Current density, Surface and volume currents, Continuity equation, Magnetic field, Biot-Savart law, Divergence and curl of magnetic field, Ampere’s law, Magnetostatic energy, Magnetostatic boundary conditions.

MAXWELL'S EQUATIONS: The equation of continuity for time varying fields, Maxwell's equations, Conditions at a boundary surface, Applications of circuit and field theory, Comparison of field and circuit theory, Maxwell's equations as generalization of circuit equations.

ELECTROMAGNETIC WAVES: Plane waves: Wave equations, plane waves in dielectric media, Plane waves in conducting media, polarization, skin effect and surface impedance, direction cosines, Reflection of plane waves: Reflection of normally and oblique plane waves from conductors and dielectrics, total reflection.

POYNTING VECTOR AND THE FLOW OF POWER: Poynting theorem, Power flow for a plane wave and power loss in a plane conductor.

Textbooks:

1. W H Hayt, J A Buck, Engineering Electromagnetics, 8th Edition, Mc-Graw Hill,2011.
2. M. O. Sadiku, Elements of Electromagnetics 4th Edition, Oxford, 2009.
3. John D. Kraus, Electromagnetics, McGraw Hill Book Co., 5th Edition, 1998.
4. E C Jordan & K. G. Balmain, Electromagnetic Waves and Radiating Systems. Second Edition, PHI, 1968.
5. Karl E. Lonngren , Sava V. Savov , and Randy V. Jost, Fundamentals of Electromagnetics with MATLAB®, 2nd Edition, 2007

Learning Resources:

1. **https://archive.nptel.ac.in/courses/108/104/108104087/**
2. **https://archive.nptel.ac.in/courses/108/102/108102119/**

EC1051	**Probability Theory and Random Processes**	PCC	**3–0–0**	**3 Credits**

Prerequisites: None

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

CO1	Understand the fundamentals of probability and random variables in continuous/discrete settings.
CO2	Identify the distribution of random variables and compute distribution of function of a random variable
CO3	Understand the concept random processes and their characterization
CO4	Characterizing the response of an LTI system to a random process
CO5	Modelling of noise in communication systems as random processes

Detailed Syllabus:

1. **Basics of Probability and single random variable**

Axioms of Probability, Probability Space, Conditional Probability, Bayes Theorem, Concept of a Random Variable, Distribution and density functions, Properties of distribution functions, Continuous random variable: Normal, Exponential, chi-square, Rayleigh, Nakagami-m, uniform distributions, Discrete random variables: Bernoulli, Binomial, Poisson distributions, Negative binomial distributions. Functions of one random variable: Expectation, Variance, Moments, Characteristic functions.

2. Random Vectors

Joint distribution and joint density functions of two or more random variables, one function of two random variable, joint moments, joint characteristic functions, conditional distributions, conditional expected values, Independence of random variables, Multivariate Gaussian distribution.

3. Random Processes

Definition of Random Processes, Distribution and density functions, statistical independence, strict sense stationary processes and wide sense stationary processes, Time averages and ergodicity, Mean ergodic process, Auto correlation function and its properties, Cross- correlation function and its properties, Covariance functions, discrete time processes and sequences, Power density spectrum and its properties.

4. LTI systems with random inputs

Response of an LTI system with input of a random process, Auto correlation functions of the response, Cross correlation functions of input and output random processes, Power density spectrum of the response.

5. Noise in Communications

Reasons for noise in communication systems, central limit theorem, modelling of noise as random process.

Text Books:

1. P.Z. Peebles.Jr., Probability, Random Variables and Random Signal Principles, Tata McGraw Hill Education, 4rd edition, 2017.
2. A.Papoulis, Probability, Random variables and Stochastic Processes, McGraw Hill, 4th edition, 2017.
3. Scott Miller, Donald Childers, Probability and Random Processes, 2 Ed, Elsevier, 2012.
4. Henry Start, and John Woods, Probability, and Random Processes with Applications to Signal Processing, Pearson, 2011
5. Leon-Garcia, Probability and Random Processes for Electrical Engineering, Pearson, 2015.

EC2011	**Analog Electronic Circuits Design**	**PCC**	**3–0–0**	**3 Credits**

Prerequisites: EC1011: Electronic Devices and Circuits

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

CO1	Design and analyze multistage amplifiers.
CO2	Apply compensation techniques for stabilizing analog circuits against parameter variations
CO3	Design negative feedback amplifier circuits and oscillators
CO4	Analyze and design solid state power amplifier circuits.

CO5	Analyze and design tuned amplifier circuits.

Detailed Syllabus:

MULTISTAGE AMPLIFIERS: Classification of amplifiers, Distortion in amplifiers, Frequency response of an Amplifier, Bode plots, Step response of an amplifier, CE short circuit current gain, High frequency response of a CE stage. Gain bandwidth product, Emitter follower at high frequencies, Analysis of Multistage amplifier, Design of two stage amplifier, Common Source and Common Drain amplifier at high frequencies. Frequency response of cascaded stages, Cascode amplifiers (CE-CB), the effect of coupling and bypass capacitors, Differential amplifiers, Analysis of Differential amplifiers.

FEEDBACK AMPLIFIERS: Classification and representation of amplifiers, Feedback concept, the transfer gain with feedback, General characteristics of negative feedback amplifiers. Impedance in feedback amplifiers. Properties of feedback amplifier topologies, approx. analysis of feedback amplifiers, Method of analysis of a feedback amplifier. The shunt feedback triple, Shunt- series pair, Series shunt pair, series triple, general analysis of multistage feedback amplifiers.

STABILITY AND RESPONSE OF FEEDBACK AMPLIFIER: Effect of feedback on bandwidth, Stability, Test of stability, Compensation, General method of compensation, Frequency response of feedback amplifier double pole transfer function. Phase Margin and gain Margin, three pole transfer function with feedback amplifier response, approximate analysis of a multi pole feedback amplifier.

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

POWER AMPLIFER: Class A, B, AB, and C power amplifiers, push – pull and complementary symmetry push-pull amplifier. Design of heat sinks, power output, efficiency, crossover distortion and harmonic distortion.

TUNED AMPLIFIER: Design and analysis of single tuned amplifier circuit with a capacitor coupled load, double tuned inter stage design. Stability consideration, Class B and class C tuned power amplifiers.

Textbooks:

1. J.Millman & Halkias, Integrated Electronics. TMH, 1991.
2. J.Millman & Arian Grabel, Micro Electronics, Second Edition TMH,1988.
3. Md.Gausi, Electronic circuits, First Edition. John Wiley,2004
4. A.S.Sedra & K.C.Smith, Micro Electronic Circuits, Seventh Edition, Oxford press, 2017

EC2031	**Microprocessors and Microcontrollers**	**PCC**	**3-0-0**	**3 Credits**

Pre-requisites: EC1031 -Digital Systems Design

CO1	Understand the architecture and operations of the 8086 microprocessor.
CO2	Interface memory and I/O devices with the 8086 microprocessor.
CO3	Understand the architecture and programming of the 8051 microcontroller.
CO4	Understand the architectural features of ARM cortex M4 microcontrollers.
CO5	Analyze ARM Cortex-M4 programming, memory system, and exception handling.

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

Detailed Syllabus:

Introduction to 8086 Microprocessors: Evolution and introduction of 80X86 microprocessor, Architecture of 8086, Register organization, Memory segmentation, Pin configuration, latching of address bus, Buffering of data bus. Minimum and Maximum mode operations. Addressing modes - Instruction set and assembler directives.

8086 interfacing: Memory interfacing: RAM, EPROM; I/O interfacing: 8255 PPI, 8257, DMA interface, Interfacing programmable interval timers – 8253/8254.

Overview of 8051 microcontroller: Architecture, Pin configuration, Stack organization. Assembly language Programming with 8051: Instruction set, Data transfer, Arithmetic, logical and branching instructions, Addressing modes, Interrupts, timer/ counter and serial communication.

Introduction to ARM Processors: Introduction to ARM processors, Evolution of ARM processors, pipeline organization, ARM Processor cores and CPU cores. Introduction to ARM Cortex-M Processors, ARM Cortex-M4 processor's architecture, Programmer's model, Special registers, Operation Modes.

ARM Cortex-M4 Programming and Memory Systems: Assembly basics, Instruction set, Data transfer and processing, Conditional and branch instructions, Cortex-M4-specific instructions, Thumb 2 instructions, Memory system overview, Memory map and access attributes, Bit-band operations, Overview of exceptions and interrupts, Interrupt management, Exception handling.

Textbooks:

1. Manish K Patel, The 8051 Microcontroller Based Embedded system, TMH, 1st Edition, 2014.
2. M.A. Mazidi, J.G. Mazidi, R.D. Mckinlay, The 8051 Microcontroller and Embedded Systems, Pearson Second Edition. 2013.
3. D. V. Hall, Microprocessors and Interfacing, TMH. Second Edition, 2006.
4. Joseph Yiu, The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors, Newnes Publications; Third Edition, 2014.
5. Ata Elahi-Trever Arjeski, ARM Assembly language with hardware experiment, Springer Int. Publishing, 2015.
6. D. A. Patterson and J. L. Hennessy, Computer Organization and Design - ARM, Morgan Kaufmann, 2010.
7. Steve Furber , ARM system on chip Architecture, Pearson Publications, Second Edition. 2000

CE1071	Environmental Science and Engineering	ESC	2-0-0	2 Cr

Pre-Requisites: None

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

CO-1	Identify environmental problems arising due to engineering and technological activities
CO-2	To understand the environmental impact of various episodes and also the effects of different types of pollutants
CO-3	Assess water demand and design components of water treatment systems
CO-4	Assess sources and effects of air and noise pollution and identify appropriate control
CO-5	Understand the techniques and methods used in transformation, conservation, and recovery of materials from solid wastes

Syllabus:

1. **Introduction**: Introduction to Environmental Pollution; Evolution of Pollution Control Strategies and Environmental Infrastructure; Major Environmental Episodes; Evolution of Environmental Acts and Policies; Environmental Ethics; Sustainability Concepts
2. **Water & Wastewater Treatment**: Water quality Standards, overview of water treatment, sources and types of pollutants, their effects, principles of wastewater treatment
3. **Air & Noise Pollution**: Sources, classification and their effects, national ambient air quality standards (NAAQS), air quality index, control of air pollution, understanding and improving indoor air quality, sources of noise pollution, effects, quantification of noise pollution.
4. **Solid Waste Management**: characteristics of solid waste, 3R concept, sustainable practices in waste management, Guidelines for solid waste management, transition to zero waste lifestyle.

Textbooks:

1. G.B. Masters, Introduction to Environmental Engineering and Science, Pearson Education, 2013.
2. Gerard Kiely, Environmental Engineering, McGraw Hill Education Pvt Ltd, Special Indian Edition, 2007.
3. Rajagopalan, Environmental Studies, Oxford IBH Pub,2011.

Reference Books:

1. W P Cunningham, M A Cunningham, Principles of Environmental Science, Inquiry and Applications, Tata McGraw Hill, Eighth Edition, 2016.
2. Environmental Studies: A Practitioner's Approach by by S. J Arceivala and S. R Asolekar, Tata McGraw- Hill Education Private Limited, 2012.
3. Rosencranz, A., Divan, S. and Noble, M.L., Environmental Law and Policy in India: Cases, Materials and Statutes, Tripathi Pvt. Ltd, Bombay, 1992.

EC1032	**Digital Systems Design Laboratory**	**PCC**	**0–0–3**	**2 Credits**

Prerequisites: None

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

CO1	Design and model combinational circuits using Verilog.
CO2	Develop Verilog models for sequential circuits.
CO3	Implement FSM-based design and pattern detectors using Verilog.
CO4	Develop and test memory modules and digital circuits on FPGA boards.

List of Experiments:

The following experiments are to be implemented on at least two different FPGA boards (Boolean Boards/Spartan/Artix) for broader practical experience.

1. Implementation of Basic logic gates and Boolean expressions through Verilog programming
2. Design and Verilog modeling of Combinational Logic circuits (Half Adder, Full Adder, Full Adder using two Half Adders)
3. Design and Verilog modeling of Combinational Logic circuits (4-bit Ripple-Carry Adder, 4-bit Carry Look Ahead Adder (CLA) Design, 4-bit Subtractor using Full Adders, 4-bit Programmable Adder/Subtractor using Full Adders).
4. Design and Verilog modeling of Combinational Logic circuits (2-to-1 Multiplexer (MUX), 4-to-1 Multiplexer (MUX), 4-to-1 Multiplexer Using Two 2-to-1 MUXes, 16-to-1 Multiplexer (MUX) Design, 2-to-4 Decoder, 4-to-16 Decoder Design, 4-to-2 Encoder Design, 4-bit Comparator).
5. Design and Verilog modeling of simple sequential circuits (Latch, Gated Latch, Positive Edge Triggered Flip-Flops with asynchronous preset and clear).
6. Design and Verilog modeling of simple sequential circuits like Counters and Shift registers (Shift Registers, Ripple Up and Down Counter Design using Flip flops, synchronous counters with enable and clear, synchronous mod-6 up counter using Flip-Flops)
7. Design and Verilog modeling of pattern detectors, FSM based design.

8. Develop Verilog codes for 4x4 Asynchronous ROM, 4x4 Synchronous ROM, 4x4 Asynchronous Read/Write Memory

9. Implementing a 4-bit Multiplier Design and Four-Input Logic Function on a Spartan-7 FPGA Using Spartan-7 FPGA.

EC2012	Analog Electronic Circuits Design Laboratory	PCC	0-0-3	2 Credits

Prerequisites: None
Course outcomes: After completion of the course, the student will be able to:

CO1	Synthesize and evaluate single multistage amplifiers
CO2	Realize the given performance using feedback amplifiers
CO3	Design and test Oscillator circuits using BJT and FET.
CO4	Design and test the Power amplifiers and Tuned Amplifiers

List of experiments:
Test and verify the following experiments using hardware components in the circuits laboratory.

1. Plot the frequency response curve and determination of voltage, current gain, input and output impedance.
   i. Two state RC coupled amplifier (Cascade configuration).
   ii. Common source JFET amplifier.
2. Determination of differential gain of a Differential amplifier using BJT.
   i. Dual input, balanced output configuration.
3. Plot the frequency response curve and determination of voltage gain and bandwidth with and without feedback.
   i. Voltage shunt feedback amplifier.
   ii. Current series feedback amplifier.
4. Determination of frequency of oscillations of RC oscillators:
   i. RC phase shift oscillator.
5. Determination of frequency of oscillations of LC oscillators:
   i. Harley Oscillator

Test and verify the following experiments using PSpice/MultiSim EDA tools.

1. Plot the frequency response curve and determination of voltage gain and bandwidth with and without feedback.
   i. Voltage series feedback amplifier.
   ii. Current shunt feedback amplifier.
2. Determination of frequency of oscillations of RC oscillators:
   i. Wein bridge oscillator.
3. Determination of frequency of oscillations of LC oscillators:
   i. Colpitts oscillator.
4. Determination of efficiency of a power amplifier.
   i. Class A Power amplifier.

5. Determine the voltage gain and frequency response: single tuned voltage amplifier.
   i. Single tuned voltage amplifier.

Hands-on practice:

Circuit design and PCB prototype Implementation of any electronics circuit for real time applications

II Year II Semester (22 Credits)

MA2081	**Numerical Techniques**	**BSC**	**2 - 0 - 0**	**2 Credits**

Prerequisite: Differential and Integral Calculus (MA1011)
Real Sequences and Differential equations (MA1081)

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

CO1	determine the numerical solution of algebraic, transcendental and system of linear equations
CO2	understand the concepts of interpolation
CO3	understand the concepts of curve fitting using least square methods
CO4	learn the techniques related to numerical differentiation and integration

Solution of Algebraic and Transcendental Equations: Numerical solution of algebraic and transcendental equations by Bisection Method , Regula-Falsi method and Newton-Raphson's method, LU Decomposition Method, Gauss elimination method, Gauss-Jacobi Iteration Method, Gauss-Seidel Iteration Method to solve a system of linear equations, Newton-Raphson's method to solve a system of nonlinear equations (12)

Interpolation : Lagrange Interpolation, Newton 's Divided Difference Interpolation, Finite Difference Operators, Newton's Forward and Backward Difference Interpolation. (6)

Numerical differentiation and integration: Numerical differentiation with forward and backward differences - Numerical Integration with Trapezoidal rule, Simpson's 1/3 rule and 3/8 rule. (4)

Numerical Solution of Ordinary Differential Equations: Taylor's method, Euler's method, Modified Euler's method, Runge-Kutta method of order 4. (6)

Text Reference:

1. M. K. Jain, S.R.K.Iyengar and R.K.Jain, Numerical methods for Scientific and EngineeringComputation, New Age International Publications, 2008.
2. Erwyn Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8th Edition, 2008.
3. B.S.Grewal, Higher Engineering Mathematics, Khanna Publications, 2009.

Reference Books:

4. D. R. Kincaid and E. W. Cheney, Numerical analysis: mathematics of scientific computing (Vol. 2). American Mathematical Soc. (2009).
5. S. S. Sastry, Introductory methods of numerical analysis. PHI Learning Pvt. Ltd., 2012.

EC2021	**Digital Signal Processing**	**PCC**	**3–0–0**	**3 Credits**

Prerequisites: Signals & Systems EC 1021

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

CO1	Find DFT of a given signal through Fast Fourier Transform Techniques
CO2	Design IIR and FIR digital filters
CO3	Identify various filter structures and evaluate the finite word length and the coefficient quantization effects
CO4	Understand the concepts of sample rate conversion techniques and its Applications

Detailed Syllabus:

DFT: Introduction and Properties of DFT, Inverse DFT, FFT algorithms – Radix-2 and Radix-4 FFT algorithms – Decimation in Time – Decimation in Frequency algorithms – Use of FFT algorithms in Linear Filtering and correlation.

IIR Filter design: Analog lowpass filter design techniques- Butterworth and Chebyshev types, methods to convert analog filters into digital filters (Impulse Invariance, Bilinear transformation, Approximation derivatives), frequency transformations for converting lowpass filters into other types.

FIR filter design: Linear phase filter, design of FIR filters using Windowing techniques – rectangular, triangular, Blackman and Kaiser windows, Frequency sampling techniques, Structure for FIR systems.

Structures for FIR and IIR filters - Direct form, cascade form and parallel structures - Lattice Structures.

Finite word length effects in filters: Fixed-point and floating-point DSP arithmetic, zero-input limit cycles in fixed point realizations of IIR digital filters-Limit cycles due to overflow.

Multirate digital signal processing fundamentals: Decimation and interpolation-time and frequency domain analysis.

Text Books:

1. J.G. Proakis and D.G. Manolakis, Digital Signal Processing - Principles, algorithms & Applications, 4th edition, PHI, 2006.
2. A.V. Oppenheim and R. W. Schafer, Discrete Time Signal Processing, 3rd Edition, PHI, 2010.
3. R. J. Schilling, S. L. Harris, Fundamentals of Digital Signal Processing using Matlab. 2^{nd} edition, Cengage Learning, 2011.

4. B. Venkataramani and M. Bhaskar, Digital Signal Processors, Architecture, Programming and Application. 2nd Edition, TMH, 2011

EC2051	Analog Communications	PCC	2–0–0	2 Credits

Prerequisites:

Signals & Systems EC 1021

Probability Theory and Random Processes EC1051

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

CO1	Compare the performance of AM, FM and PM schemes with reference to SNR
CO2	Compare the performance of AM, FM schemes
CO3	Convert Analog signal to Digital Signal
CO4	Compare the performance of PCM, DPCM and DM
CO5	Understand FDM & TDM multiplexing techniques

Detailed Syllabus:

Fundamentals of Analog communication systems: Block schematic, Modulation and frequency translation, Lowpass and bandpass signals, Concept of complex envelope, Hilbert transform and phase shifting.

Linear continuous wave (CW) modulation: AM, DSB/SC, SSB, VSB, methods of generation; Nonlinear modulation techniques: FM and PM, narrowband FM, wideband FM, methods of generation.

Demodulation: Demodulation techniques of CW modulation, Demodulation techniques for FM, threshold effect in FM, pre-emphasis and de-emphasis, Superheterodyne receiver, Tuned radio frequency receiver, Noise in receivers, Noise figures, Performance of analog modulation schemes in AWGN: SNR and figure of merit for different schemes. TDM, FDM.

Pulse Analog Modulation – Pulse Amplitude Modulation, Pulse width Modulation, Pulse Position Modulation.

Baseband communication: Time division multiplexing with PAM, Quantization, Pulse Code Modulation (PCM), Differential PCM, Delta modulation, Adaptive Delta Modulation, Noise analysis in PCM and Delta modulation, Line coding schemes, Power and bandwidth efficiency, Nyquist's criteria, pulse shaping.

Textbooks:

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

2. B.P. Lathi, Modern Digital & Analog Communications Systems, 5th Edition, Oxford University Press, 2019
3. J. G. Proakis, M. Salehi, Communication Systems Engineering, 2nd Edition, Prentice Hall, 2002.
4. Herbut Taub, and Donald L. Schilling, Principles of Communication Systems, 4th Edition, Pearson, 2017.

EC2061	Control Systems	PCC	3–0–0	3 Credits

Pre-requisites: Differential equations and Transform Techniques, Network Analysis, Signal and systems.

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

CO1	Understand the fundamental concepts of open-loop and closed-loop control systems
CO2	Develop mathematical models of dynamic systems using differential equations, transfer functions, and state-space representations.
CO3	Analyze system stability and performance using time-domain and frequency-domain techniques.
CO4	Design controllers (PID, lead-lag, state feedback) for desired performance.

Detailed syllabus:

Introduction to Control systems: Definition and applications of control systems, Basic components of control System, Open-loop vs. closed-loop control, Feedback characteristics of control systems, Introduction to modern control applications (robotics, aerospace, automation)

Mathematical Modelling of Control Systems: Differential Equation form for electrical, mechanical and electro-mechanical systems, Transfer Functions and block diagrams for Simple Electrical Networks and mechanical systems, state space representation, Block Diagram Reduction Techniques, Signal Flow Graphs, Mason's Gain Formula.

Time Domain Analysis: Transient and steady-state response, Time Response of First and Second Order System for impulse, step and ramp inputs, Time Domain- Specifications (peak time, rise time, overshoot, settling time), Steady State Error Analysis. Concept of stability: BIBO stability, absolute stability; Routh-Hurwitz Criterion, Root Locus Analysis - Effect of Pole Zero Additions on Root Locus.

Frequency Domain Analysis – Frequency response of closed-loop control systems, frequency domain specifications, Correlation between Time and Frequency Response, Nyquist, Polar Plot, and Bode Plot, All pass and minimum phase systems, Nyquist Stability Criterion, and its application for systems with minimum phase transfer function, Relative stability, Gain and Phase Margin.

Introduction to compensation networks - Lag, Lead, Lag-Lead and Lead-Lag compensation networks, Effects of compensation networks on system performance, Proportional (P), Integral (I), and Derivative (D) control, design of P, PI, PD and PID Controllers.

State-Space Analysis: State variables and State-space representation of dynamic systems, Solution of state equations, Concept of Controllability and observability, State feedback control, Pole placement by state feedback.

Textbooks:

1. I.J. Nagarath and M. Gopal: Control Systems Engineering, 5th Edition,New Age Pub. Co.2008.
2. B.C. Kuo, Automatic Control Systems, 10th Edition, McGraw-Hill Education, 2017.
3. Kausuhio Ogata, Modern Control Engineering, Prentice Hall of India PVT. Ltd, 5th Edition, 2010.
4. Richard Dorf, Modern Control Systems, Pearson Education Ltd, 13th Edition, 2017.
5. A. Nagoorkani, Control System, RBA Publications, 3rd Edition, reprint 2012.

EC3011	Linear Integrated Circuits and Applications	PCC	2-0-0	2 Credits

Pre-requisites: Electronic Devices and Circuits and Analog Electronics Circuits and Applications

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

CO1	Design op-amp circuits to perform arithmetic operations.
CO2	Analyze and design linear and non-linear applications using op-amps.
CO3	Analyze and design oscillators and filters using functional ICs.
CO4	Choose appropriate A/D and D/A converters for signal processing applications.

Detailed Syllabus:

Ideal Characteristics of op-amp, Pin configuration of 741 op-amp. Op-amp parameters and their measurement.

Inverting and non-inverting amplifiers; Applications: inverting and non- inverting summers, difference amplifier, differentiator and integrator, Voltage to current converter. Instrumentation amplifier, Log and antilog amplifiers. Precision rectifier, Non-linear function generator.

Comparators, Astable and Monostable multi vibrator, Triangular wave- generators, RC-phase shift oscillator, Wein's bridge oscillator, Schmitt trigger, 555 Timer.

Low pass, High pass, Band pass and Band Reject filters, Butterworth, Chebychev filters.

PLL- basic block diagram and operation, capture range and lock range; applications of PLL IC 565, AM detection, FM detection and FSK demodulation. VCO IC 566.

Series op amp regulator, three terminal IC voltage regulators. IC 723 general purpose regulator, Switching Regulator.

Digital to Analog and Analog to Digital converters: Weighted resistor DAC, R-2R and inverted R-2R DAC.

Textbooks:

1. G B Clayton, Operational Amplifiers, 5th Edition, Elsevier science, 2003
2. Ramakant A. Gayakward, Op-Amps and Linear Integrated Circuits, 4th Edition, PHI, 2010
3. Roy Choudary D. and Shail B. Jain, Linear Integrated circuits, 4th Edition, New Age International Publishers, 2010
4. Sergio Franco, Design with Operational Amplifier and Analog Integrated Circuits, 4th Edition, McGraw-Hill Series, 2015.

EC2022	Digital Signal Processing laboratory	PCC	0-0-3	2 Credits

Pre-requisites: None
Course Outcomes: After the completion of the course the student will be able to:

CO1	Represent and analyze signals/systems in time and frequency domains using MATLAB/Python
CO2	Design and simulate FIR/IIR filters for real-world applications in signal processing and communications.
CO3	Implement DSP algorithms e.g. convolution, DFT/FFT and digital filters on a DSP processor.
CO4	Compare theoretical DSP concepts (e.g., filter structures, word-length effects) with practical results from hardware/software experiments.

List of Experiments:

PART I: MATLAB/PYTHON BASED EXPERIMENTS

1. Time and Frequency domain Representation of continuous and discrete-time signals
   (a) Generate and plot common continuous-time and discrete-time signals.
   (b) Compute and plot the Fourier transform of finite length signals.

2. Time and Frequency domain Representation of LTI systems
   (a) Compute linear convolution of two finite length sequences.
   (b) Simulate an LTI system using the difference equation representation.
   (c) Compute and plot the impulse response, frequency response and system function (pole-zero plot) of an LTI system.

3. DFT and Spectral Analysis of signals
   (a) Compute circular convolution of two finite length sequences.

(b) Validate properties of the DFT/IDFT.
(c) Compute and plot the magnitude/phase spectra of a signal using DFT.
(d) Study the effect of DFT length and the windowing (frequency resolution and amplitude resolution)

4. Efficient Computation of DFT
(a) Design and simulate the 2nd Order Goertzel Algorithm.
(b) Implement Radix-2,3,4 FFT Algorithms.

5. IIR Filter Design
(a) Design frequency selective filters (Lowpass, Highpass, Bandpass and Bandstop) using the bilinear transform method.
(b) Apply IIR filters to practical problems like noise filtering and demodulation.

6. FIR Filter Design
(a) Design frequency selective filters using the windowing method.
(b) Design frequency selective filters using the Parks-McClellan algorithm).
(c) Apply FIR filters to practical problems like noise filtering and demodulation.

7. Digital Filter Structures
(a) Convert between direct/parallel and cascade structures of a given filter.
(b) Analyze effects of filter coefficients quantization on different filter structures.

8. Sample Rate Conversion
(a) Reduce the sampling rate of a signal by an integer factor.
(b) Increase the sampling rate of a signal by an integer factor.
(c) Resample a signal by a rational factor.

PART II: TMS320C6758 LCDK based Experiments

1. Introduction to LCDK Hardware and Code Composer Studio (CCS).
2. Implementation of Linear and Circular Convolution on DSP processor using CCS.
3. Implementation of DFT for on a DSP processor using CCS.
4. Implementation of FFT algorithms on a DSP processor using CCS.
5. Design and Implementation of FIR Filters on a DSP processor (using CCS and MATLAB).
6. Design and Implementation of IIR Filters on a DSP processor (using CCS and MATLAB).

Textbooks:

1. Ingle, V. K., Proakis, J. G, Digital Signal Processing Using MATLAB (3rd ed.). Cengage (2016).
2. Oppenheim, A. V., & Schafer, R. W. Discrete-Time Signal Processing (3rd ed.). Pearson (2010).
3. Proakis, J. G., & Manolakis, D. G. Digital Signal Processing: Principles, Algorithms, and Applications (4th ed.). Pearson (2007).

EC2032	**Microprocessors and Microcontrollers Laboratory**	**PCC**	**0-0-3**	**2 Credits**

Pre-requisites: EC1032 -Digital Systems Design Laboratory
Course Outcomes: After the completion of the course the student will be able to:

CO1	Develop assembly language programs for the 8086 microprocessor.
CO2	Implement basic programming, timers, counters, and serial communication using the 8051 microcontroller.
CO3	Write and execute assembly programs for the ARM Cortex-M4 processor.
CO4	Interface and control peripheral devices using 8051 and ARM trainer kits.

Indicative list of Experiments:

1. 8086 Microprocessor Programming – Assembly language programming for basic arithmetic operations including addition, subtraction, multiplication, division, multiply-accumulate operations, along with matrix addition, subtraction, and multiplication using EMU8086.
2. 8051 Microcontroller Programming – Understanding basic instructions, implementing timer and counter applications, serial communication using Keil simulator.
3. ARM Cortex-M4 Processor Programming – Assembly language programming for low-level operations, instruction set utilization using Keil simulator.
4. Flashing of LEDS on 8051 and ARM Trainer kit
5. Interfacing ADC on 8051 and ARM Trainer kit
6. Interfacing DAC on 8051 and ARM Trainer kit
7. Interfacing 7-Segment LED on 8051 and ARM Trainer kit
8. Interfacing of Analog Keypad on 8051 and ARM Trainer kit
9. Interrupt using on board push button on 8051 and ARM Trainer kit
10. Interfacing stepper motor with 8051 and ARM Trainer kit
11. Interfacing temperature sensor with 8051 and ARM Trainer kit.

Textbooks:

1. Manish K Patel, The 8051 Microcontroller Based Embedded system, TMH, 1st Edition, 2014
2. M.A. Mazidi, J.G. Mazidi, R.D. Mckinlay, The 8051 Microcontroller and Embedded Systems, Pearson Second Edition. 2013.
3. D. V. Hall, Microprocessors and Interfacing, TMH. Second Edition, 2006.
4. Ata Elahi-Trever Arjeski, ARM Assembly language with hardware experiment, Springer Int. Publishing, 2015.

MA2082	Computational Numerical Methods	BSC	0-0-2	1 Credits

Pre-requisites: Differential and Integral Calculus (MA1011)

Real Sequences and Differential equations (MA1081)

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

CO 1	write computer programs to solve engineering problems with Python Language.
CO 2	implement numerical methods in Python Language.
CO 3	to solve linear systems.
CO 4	to solve ordinary differential equations.

Solution of algebraic and transcendental equation: Bisection method, Newton-Raphson method, Fixed-point iteration scheme.

Solution of linear systems: Gaussian elimination, Jacobi, Gauss Seidel methods.

Integration: Trapezoidal rule, Simpson's 1/3, and 3/8-rules.

Ordinary Differential Equations: Taylor series, Euler's method, Modified Euler's method, Runge-Kutta method

Textbooks:

1. Erwin Kreyszig, Advanced Engineering Mathematics, Eighth Edition, John Wiley and Sons, 2015.
2. S. D. Conte and C. de Boor, Elementary Numerical Analysis: An Algorithmic approach, 3rd edition, McGraw-Hill Book Company, New York, 1980.
3. Q. Kong, T. Siauw, & A. Bayen, Python programming and numerical methods: A guide for engineers and scientists. Academic Press, 2020.
4. M. K. Jain, S.R.K.Iyengar and R.K.Jain, Numerical methods for Scientific and Engineering Computation, New Age International Publications, 2008.
5. K. E. Atkinson, Introduction to Numerical Analysis, 2nd Edition, John Wiley,New York, 1989.

HS2011	Personality Development	BSC	1-0-0	1 Credits

Course outcome:

CO1	Students will develop a deeper self-awareness, gaining insights into their strengths, weaknesses, values, and emotional triggers.
CO2	Students will enhance their communication skills, enabling them to express themselves more clearly and engage effectively with others.
CO3	Students will improve their emotional intelligence and cultivate a growth mindset, equipping them to navigate challenges with resilience and adaptability.
CO4	Students will strengthen their abilities in conflict management, adaptability, and networking, preparing them for successful interactions in personal and professional contexts.

Syllabus

Module 1
Introduction to personality development - self assessment- SWOT - personal values statement - (punctuality, attitude, responsibility, ethics, integrity, values, and trust, and self-confidence) - imposter syndrome, communication skills (verbal and non-verbal, body language and posture, avoiding miscommunication) - techniques for persuasive communication - key principles to increase clarity of communication

Module 2
Emotional Intelligence - ways to improve emotional intelligence - application of emotional intelligence - identifying emotional triggers - Building rapport and maintaining positive interactions - Fixed and growth mindset - emotions in personal and professional relationships, strategies for effective networking - social and dining etiquette - greetings - dress code.

Textbooks:

Mitra, Barun K. Personality Development and Soft Skills. 2nd ed. Oxford Higher Education, 2016.

Sharma, Prashant. Soft Skills: Personality Development for Life Success. 3rd ed. BPB Publications, India, 2022.

Goleman, D. (1995). Emotional intelligence: Why it can matter more than IQ. Bantam Books.

Carnegie, D. (2020). How to win friends and influence people. Srishti Publishers and Distributors.

Khera, S. (2014). You can win: A step-by-step tool for top achievers. Bloomsbury India.

III Year I Semester (22 Credits)

EC2041	Transmission Lines and Antennas	DEC	3–0–0	3 Credits

Pre-requisites: Engineering Electromagnetics

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

CO1	Introduce various types of transmission lines and analyze the lumped circuit model of a transmission line and their characteristics.
CO2	Use the smith chart as a graphical tool to solve impedance matching problem
CO3	Apply the knowledge of transmission line theory to waveguides
CO4	To understand the fundamental concept of radiation phenomena and analyze the radiation characteristics of various antennas and antenna arrays.

Detailed Syllabus:

Transmission Lines: Circuit model for a transmission line, Field analysis, Distortion less transmission lines, Phase and group velocities, Input impedance of transmission line, loading of lines.

Application of Transmission Lines: RF lines, Lossless transmission lines, Relation between reflection coefficient, Load and characteristics impedance, Relation between reflection coefficient and voltage standing wave ratio, Line of different lengths λ/8, λ/4, λ/2, Losses in transmission lines, smith chart, Impedance matching with single and double stubs, Quarter-wave transformer.

Guided Wave Propagation: Review on Maxwell Equations, Fields in Media and Boundary Conditions, Helmholtz Equation, General solutions for TEM, TE, and TM waves, parallel plate waveguide, rectangular waveguide, circular waveguide, Microstrip, Stripline.

Antennas: Basic radiation principle, Radiation from a Hertizian dipole, Monopole and a half wave dipole, Fields in the vicinity of an antenna and far-field approximation, Fundamental parameters of antenna, Antenna arrays.

Narrowband and wideband Antennas: Wire antennas, Loop antennas, Travelling and Broadband antennas, Aperture antennas, Horn antennas, Reflector antennas, Frequency independent antennas, Microstrip or patch antennas and its simulations.

Textbooks:

1. Pozar, David M. Microwave engineering. John wiley & sons, 2011.
2. Balanis, Constantine A. Antenna theory: analysis and design. John wiley & sons, 2015.
3. W. H. Hayt, “Engineering Electromagnetic”, 5th Ed., TMH, 1999.

4. J. D. Krauss, “Antennas”, McGraw - Hill Inc., New York, 4th Ed. (1991).
5. E C Jordan & K. G. Balmain, Electromagnetic Waves and Radiating Systems. Second Edition, PHI, 1968

Learning Resources

1. **https://archive.nptel.ac.in/courses/117/101/117101056/**
2. **https://archive.nptel.ac.in/courses/108/101/108101092/**

EC3051	**Digital Communications**	**PCC**	**3–0–0**	**3 Credits**

Prerequisites: EC1051 Probability Theory and Random Processes

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

CO1	Model a Digital Communication System
CO2	Represent a signal as a linear combination of orthogonal signals
CO3	Generate modulated waveforms with desired carrier frequency and bandwidth
CO4	Compare performance of various digital modulation techniques
CO5	Design methods to remove inter-symbol interference

Detailed Syllabus:

Signal Space Analysis: Model of Digital Communication Systems, Representation of Band-pass signals and systems, Geometric representation of signals, Gram-Schmidt Orthogonalization, Constellation diagrams.

Digital Modulation Techniques: Modulation techniques: M-ASK, M-FSK, M-PSK, M-QAM. Raised cosine pulse, spectral characteristics of modulated signals.

Performance Of Digital Modulation Techniques over AWGN channel: MAP and ML criterion, matched filter receiver, correlation receiver. SER analysis of M-ASK, M-FSK, M-PSK, and M-QAM and their comparison.

Carrier and Symbol Synchronization: Signal parameter estimation, Carrier phase estimation: ML estimation, Phase-locked loop, symbol timing estimation.

Communication through Band-limited Channels: Signal design for band-limited channels, Optimum receiver for channels with ISI and AWGN, Eye diagrams, Viterbi algorithm, Linear equalization, Decision-feedback equalization, Adaptive equalization.

Textbooks:

1. Simon Haykin , Communication Systems , 5th Edition, 2009, Wiley India Pvt. Ltd,
2. John G Proakis, Digital Communicatons, 4th Edition, 2001, McGrawHill.
3. B Sklar, Digital Communications: Fundamentals and Applications, 2001, Pearson Education.

4. Upamanyu Madhow, Fundamentals of Digital Communication, 2008, Cambridge University Press

EC2052	Communication Engineering Laboratory	PCC	0-0-3	2 Credits

Pre-requisites: None

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

CO1	design and implement different analog/digital modulation and demodulation schemes
CO2	generate and demodulate pulse modulation schemes and compare their time-domain and spectral characteristics.
CO3	simulate BPSK, DPSK and QPSK based communication systems, plot constellation diagrams, and assess their bit error rate (BER) performance.
CO4	validate theoretical concepts through practical observations.

List of Experiments:

1. Amplitude Modulation (AM) and Demodulation: Perform amplitude modulation and demodulation for different modulation index using MATLAB/ Simulink and a practical setup.
2. Frequency Modulation (FM) and Demodulation: Perform frequency modulation and demodulation and observe waveforms using MATLAB/Simulink and a practical setup.
3. Pulse Amplitude Modulation (PAM) and Demodulation: Study PAM generation (natural/flat-top sampling) and reconstruction using MATLAB/ Simulink and a practical setup.
4. Pulse Width Modulation (PWM) and Demodulation: Study PWM signal generation and demodulation using MATLAB/ Simulink and a practical setup.
5. Pulse Position Modulation (PPM) and Demodulation: Study PPM signal generation and demodulation using MATLAB/ Simulink and a practical setup.
6. Amplitude Shift Keying (ASK) Modulation and Demodulation: Study ASK modulation and demodulation using MATLAB/ Simulink and a practical setup.
7. Frequency Shift Keying (FSK) Modulation and Demodulation: Study FSK modulation and demodulation using MATLAB/ Simulink and a practical setup.
8. Phase Shift Keying (PSK) Modulation and Demodulation: Study PSK modulation and demodulation using MATLAB/ Simulink and a practical setup.
9. Differential PSK (DPSK) Modulation and Demodulation: Study DPSK modulation and demodulation using MATLAB/ Simulink and a practical setup.
10. Quadrature PSK (QPSK) Modulation and Demodulation: Study QPSK modulation and demodulation using MATLAB/ Simulink and a practical setup.

Textbooks:

1. Proakis, J. G., & Salehi, M. 2001. Communication Systems Engineering (Second). Upper Saddle River, NJ, USA: Prentice-Hall.
2. Gerhard Bauch, John G. Proakis, Masoud Salehi, “Modern Communication Systems Using MATLAB,” Cengage 2013.
3. Haykin, S., & Moher, M. “Introduction to analog and digital communications” (2nd ed.). Wiley.
4. Taub, H., Schilling, D. L., & Saha, G. (2008). Principles of communication systems (3rd ed.). Tata McGraw-Hill.

EC3012	**Linear Integrated Circuits and Applications Laboratory**	**PCC**	**0–0–3**	**2 Credits**

Prerequisites: (E1011 and EC2011) Electronic Devices and Circuits and Analog Electronic Circuits and Applications

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

CO1	To experimentally study Op-Amp Characteristics and its applications
CO2	To study Astable and Monostable Multivibrators
CO3	To study frequency response of various filters
CO4	To study voltage regulators

ANALOG IC EXPERIMENTS:

1. Study of operational Amplifier (op-amp) and measurement of Op- amp parameters: Offset Voltage. Offset Current, CMRR and Slew rate

2. Op-amp applications: (a) Inverting and non-inverting Amplifiers using Op-amp. (b) adder and subtractor using op-amp

3. Integrator and Differentiator using op-amp

4. Astable and monostable multivibrator using op-amp

5. Frequency response of active filters: LPF, HPF and BPF

6. Astable and Monostable Multivibrator using IC 555

7. Voltage Regulator using IC 723

DIGITAL IC EXPERIMENTS:

1. Verification of Logic Gates and their applications

2. Parallel Adder and Subtractor

3. Multiplexer and Demultiplexer
4. Verification of Flipflops
5. Verification of Decade Counter using IC 7490 and 4-Bit Binary Up/Down Counter
6. Analog To Digital Converter (ADC) Using IC

SM 3021	**Design Thinking**	**SM**	**1 – 0 – 0**	**1 Credit**

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

CO1	Understand and apply advanced Design Thinking techniques for problem-solving.
CO2	Develop proficiency in ideation and visualization tools to structure innovative concepts, analyze biases in user and developer perspectives to enhance communication.
CO3	Implement frameworks to sustain a culture of innovation, apply Design Thinking principles to real-world challenges through exercises and case-based discussions.

Detailed Syllabus:

Listening and empathizing techniques, observation techniques, structured open-ended approaches, overcoming cognitive fixedness, behavior models, innovation heuristics, case-based discussions-exercises.

Use of diagrams and maps in design thinking, empathy map, affinity diagram, mind map, journey map-combining ideas into complex innovation concepts, storytelling and scenario planning-improvisation, scenario development, evaluation tools, frog design-prototyping, interactive workshops, case-based discussions.

Textbooks:

1. Roger Martin, The Design of Business: Why Design Thinking is the Next Competitive Advantage, Harvard Business Press , 2009.
2. Christoph Meinel, Larry Leifer, and Hasso Plattner (eds), Design Thinking: Understand – Improve– Apply, Springer, 2011.
3. Idris Mootee, Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School, John Wiley & Sons, 2013.

CSXXXX	**Design and Analysis of Algorithms**	**ESC**	**1–0–0**	**1 Credits**

Prerequisites: None

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

CO1	Analyze the efficiency of algorithms using asymptotic notations and solve recurrence relations through substitution, recursion-tree, and master theorem methods.
CO2	Design and evaluate various sorting and selection algorithms, including heapsort, quicksort, radix sort, and linear-time selection techniques.
CO3	Apply advanced algorithmic concepts for polynomial computations and demonstrate an understanding of NP-completeness and problem reductions.

Detailed Syllabus:

FOUNDATIONS

Growth of Functions: Asymptotic notation, Standard notations and common functions, Divide-and-Conquer: The maximum-subarray problem, Strassen's algorithm for matrix multiplication, the substitution method for solving recurrences, the recursion-tree method for solving recurrences, the master method for solving recurrences, Proof of the master theorem.

SORTING AND ORDER STATISTICS

Heapsort: Heaps, Maintaining the heap property, building a heap, the heapsort algorithm, Quicksort: Description of quicksort, Performance of quicksort, A randomized version of quicksort, Analysis of quicksort, Sorting in Linear Time: Lower bounds for sorting, counting sort, Radix sort, Bucket sort, Medians and Order Statistics: Minimum and maximum, Selection in expected linear time, Selection in worst-case linear time.

SELECTED TOPICS

Polynomials and the FFT: Representing polynomials, The DFT and FFT, Efficient FFT implementations, NP-Completeness: Polynomial time, Polynomial-time verification, NP-completeness and reducibility, NP-completeness proofs, NP-complete problems.

Textbooks:

1. Cormen, Thomas H., Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. Introduction to algorithms. MIT press, 2022.
2. Michael T. Goodrich, R. Tamassia, and Mount, Data Structures and Algorithms in C++, Second Edition, John Wiley and Sons, 2011.

III Year II Semester (22 Credits)

EC3031	VLSI Design	PCC	3-0-0	3 Credit

Prerequisites: EC1011 Electronics Devices and Circuits

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

CO1	Explain the fabrication, operation and characteristics MOSFET
CO2	Analyse the performance of CMOS inverter
CO3	Design Digital circuits using CMOS gates
CO4	Design Analog circuits using CMOS gates
CO5	Outline the latest trends in CMOS technology

Course Articulation Matrix:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	L	M	-	-	-	-	-	-	-	-	-	M	-
CO2	S	M	S	-	-	-	-	-	-	-	-	-	M	M
CO3	S	S	S	-	-	-	-	-	-	-	-	-	M	M
CO4	S	S	S	-	-	-	-	S	-	-	-	-	M	M
CO5	L	M	-	-	-	-	S	-	-	-	-	-	M	M

S: Strong correlation, M: Medium correlation, L: Low correlation

Detailed Syllabus:

INTRODUCTION to MOSFETs: Unit process steps of CMOS technology, Fabrication process flow: NMOS, PMOS, Twin well CMOS; Structure and operation of the MOS transistor, I-V and C-V characteristics, MOSFET capacitances, layout, design rules, Body effect, Channel Length Modulation, Scaling and Short channel effects.

MOS INVERTERS: Inverters with resistive, MOSFET load; CMOS inverter: Voltage transfer characteristics, Noise margins, switching characteristics, calculation of delay times; effect of load on switching characteristics and driving large loads, logical effort of paths, power dissipation issues.

Digital circuits using CMOS: Pseudo NMOS, Pass transistor, transmission gates, Dynamic logic, Domino logic, Differential cascade voltage switch logic, design of combinational circuits, design of sequential circuits, timing requirements, Schmitt trigger circuit.

Analog circuits: Second order effects in MOSFETs. Single stage Amplifiers: Common-source stage, Source follower, Common-gate, Cascode stage, Differential Amplifiers, Passive and Active current mirrors, CMOS operational amplifier, gain boosting techniques.

Trends in CMOS technology: SOI, GAAFET, FinFET and multi-gate FET, 2D materials-based FETs, On-chip interconnects.

Textbooks:

1. Sung-Mo Kang, Yusuf Leblebici Chulwoo kim, Digital Integrated Circuits: Analysis and Design, 4th Edition, McGraw Hill Education, 2016.
2. Behzad Razavi, Design of Analog CMOS Integrated Circuits, 2nd Edition, McGraw Hill Education, 2016.
3. Jan M RABAEY, Digital Integrated Circuits, 2nd Edition, Pearson Education, 2003.
4. Neil H.E. Weste and David Harris, CMOS VLSI Design: A circuits and systems perspective, 4th Edition, Pearson Education, 2015.
5. P. P. Sahu, VLSI Design, McGraw Hill Publication. 2013

EC 3041	**Microwave Engineering**	**PCC**	**2-0-0**	**2 Credits**

Pre-Requisites: EC1041 Engineering Electromagnetics

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

CO-1	Understanding of the Guided wave propagation.
CO-2	Study of different analytical techniques (S-Matrix, ABCD matrix) involved in design of microwave components.
CO-3	Understanding of microwave passive circuits.
CO-4	Study the performance of specialized microwave tubes such as klystron, reflex klystron, and cavity magnetron.
CO-5	Study the performance of semiconductor-based microwave sources.

Syllabus:

Scattering Matrix: Impedance and admittance matrices of microwave network, scattering matrix (S-Matrix) and its Properties, Transmission (ABCD) Matrix, Excitation techniques for waveguides.

Passive Networks: Three ports and four port microwave junctions, T-junction power divider, Wilkinson power divider, qualitative description of two-hole and multi-hole waveguide couplers, hybrid junctions; Faraday rotation, ferrite circulators, isolators and phase shifters.

Microwave Sources: Operation and application of Klystron amplifier, Reflex Klystron oscillator, Travelling Wave tube amplifier and Cavity magnetron.

Microwave semiconductor-based devices: Operation and applications of PIN Diode, Gunn diode, IMPATT diode, PIN Diode, and Schottky barrier diode; Microwave BJT, MESFET, HEMT and their applications.

Textbooks:

1. Pozar, D.M., Microwave Engineering, 4th Ed., John Wiley & Sons, 2012.
2. Liao, S.Y., Microwave Devices and Circuits, 3rd Ed Pearson India. 2000.

3. Collin, R.E., Foundations for Microwave Engineering, 2nd Ed., John Wiley & Sons.2001.

Learning Resources:

1. **https://archive.nptel.ac.in/courses/108/103/108103141/**

EC4051	Wireless Communications	PCC	3–0–0	3 Credits

Prerequisites:

Digital Communications EC3051

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

CO1	Understand wireless channel model
CO2	Compute probability of error for modulation schemes over wireless channel
CO3	Design methods to combat outage
CO4	Understand channel assignment strategies in cellular systems

Detailed Syllabus:

Wireless Channel: Radio wave propagation, Large-scale fading: free-space path loss, ray tracing, empirical path-loss models, simplified path loss model, shadow fading, outage probability under path loss and shadowing, cell coverage area. Small-scale fading: Time-varying channel impulse response (I/O model), Narrowband and Wideband models, power delay profile, coherence bandwidth, coherence time, doppler power spectrum, space-time channel model.

Cellular Concept: Frequency reuse, channel assignment strategies, handoff strategies, interference and system capacity, trunking and grade service, Improving coverage in cellular systems: cell splitting, sectoring, repeaters for range extension, microcell zone.

Modulation Techniques: Review of M-PAM, M-PSK, M-QAM modulation. Error probability for M-PSK, M-PAM, and M-QAM modulation techniques over wireless channels. Outage probability, average probability of error, Doppler spread and Inter symbol interference.

Diversity: Receiver diversity: selection combining, threshold combining, maximal ratio combining, Transmit diversity: with and without channel information at transmitter, Alamouti scheme, moment generating function in diversity analysis.

Multicarrier Modulation: Orthogonal frequency division multiplexing (multi-carrier modulation, OFDM transmitter/receiver design, cyclic prefix), multicarrier modulation with overlapping subcarriers, mitigation of subcarrier fading, challenges in multicarrier systems: peak-to-average power ratio, frequency and timing offset.

Multiple antenna techniques MIMO transmitter and receiver, advantages of multiple antennas, diversity and spatial multiplexing gain.

Evolution of cellular communications from 1G to 5G.

Text Books:

1. Andea Goldsmith, Wireless Communications, 2005, Cambridge University Press.
2. Theodore S Rappaport, Wireless Communications: Principles and Practice, 2nd edition, 2002, PHI.
3. David Tse, Pramod Viswanath, Fundamentals of Wireless Communication, 2005, Cambridge University Press.

SM 3011	Introduction to Entrepreneurship	SM	1 – 0 – 0	1Credit

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

CO1	Acquaint themselves with starting new ventures and introducing new products and service ideas
CO2	Explore the processes of establishing a start-up and develop strategies and methods to mobilize resources
CO3	Create venture capitalists, consultants to new firms or new business development units of larger corporates

Detailed syllabus:

The entrepreneur's role, task, and personality- typology of entrepreneurs: entrepreneurship as a style of management

Identify problems worth solving-political economical, and social- technical analysis-opportunity recognition-business model identification-new product franchising- sponsorship and acquisition- internal & external entry strategies

Startup ecosystem and support system- role of incubators- government initiatives

Writing and pitching business plan-entrepreneurial tool-venture capital and other forms of financing-sources of external support-developing entrepreneurial marketing-competencies-maintaining competitive advantage

Textbooks:

1. B.D.Singh. *Managing Conflict and Resolution.* Excel Books.2008

2. B. R. Barringer and D. Ireland, *Entrepreneurship*, Prentice Hall,2009.

3. G. Kawasaki, L. Filby, *The Art of the Start 2.0: The Time-Tested, Battle-Hardened Guide for Anyone Starting Anything* , Penguin,2015.

4. R. Bansal, *Connect the Dots,* Westland, 2011.

5. Ries, Eric *The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses,* Crown Business, 2011.

6. S. S. Khanka, *Entrepreneurial Development,* S. Chand & Co.2006.

IV Year I Semester (22 Credits)

EC3042	**Microwave And Optical Communications Laboratory**	**PCC**	**0–0–3**	**1 Credits**

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

CO1	Measure performance of simple microwave circuits and devices.
CO2	Perform microwave measurements with sophisticated instruments such as vector network analyzer and spectrum analyzer
CO3	Assess the performance of optical devices: light sources, fibers and detectors.
CO4	Plot the loss characteristics of optical fibers.

List of Experiments:

1. Study of mode characteristics of reflex klystron.
2. Study of gunn oscillator I-V characteristics.
3. Frequency & wavelength measurement of a rectangular waveguide working in TE10 mode.
4. Study the characteristics of circulators & Directional couplers.
5. Study the properties of the Magic Tee Junction.
6. Demonstration of Vector Network Analyzer.
7. S-parameter measurement of microstrip components using Vector Network Analyzer (VNA).
8. Numerical Aperture measurement of optical fiber.
9. Study of Optical Sources, Detectors and fiber optic communication link.

Departmental Electives: Communications and Signal Processing stream

EC3111	**Optimization Techniques**	**DEC**	**3–0–0**	**3 Credits**

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

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

Detailed Syllabus:

Introduction: Statement of an optimization problem, Classification of optimization problems, Overview of various optimization Techniques.
Linear Programming: Definition, Fundamental theorem of linear programming, The simplex algorithm, duality, Primal-Dual method
Unconstrained optimization: Definitions and existence conditions, General properties of minimization algorithms, Line search, The Steepest-Descent Optimization Technique, Newton's method, The Least-p^{th} Optimization Technique- Least square Algorithm. Convex functions, optimality conditions for convex optimization problems
Constrained optimization: Active Constraints versus Inactive constraints, Transformations, penalty functions, Karush-Kuhn Tucker conditions, sufficiency of KKT conditions for convex optimization problems.
Advanced Techniques for Optimization:
Genetic algorithm (GA): Fundamentals of Genetic algorithm, History, Basic concepts, working principle, Applications of GA for standard Benchmark test functions.

Swarm intelligence: Main inspiration source, early variants of PSO, Basic particle swarm optimization, Initialization techniques, Theoretical investigations and parameter selection, Design of PSO algorithm using computational statistics, Termination conditions. Application of PSO, Standard test function optimization.

Textbooks:

1. Richard W Daniels, An Introduction to Numerical Methods and Optimization Techniques, Elsevier North Holland Inc,
2. Milani Mitchel, An introduction to Genetic algorithms, 5th Edition, The MIT Press, 1999.
3. AE Eiben and J.E Smith, Introduction to Evolutionary Computing, 2nd Edition, Springer 2015.
4. Weifan Wang, Xuding Zhu, Ding-Zhu Du, Combinatorial Optimization and Applications:5th International Conference, Springer Publications, 2011
5. Stephen Boyd, L Vandenberghe, Convex optimization, Cambridge university press.

EC3121	Data Networks	DEC	3-0-0	3 Credits

Pre-requisites: EC1051 Probability Theory and Random Processes

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

CO1	Identify and explain the fundamental concepts of network architecture, protocols, internetworking principles, and network security.
CO2	Analyze data link layer protocols, including error detection, flow control and MAC methods.
CO3	Understand the concepts of Wide Area Networks, such as switching, routing, congestion, and QoS.
CO4	Design and evaluate network addressing schemes using IPv4 (subnetting, CIDR, NAT) and contrast them with IPv6.
CO5	Understand and implement Transport and Application layer protocols.

Detailed Syllabus:

Introduction: Basics of Data Communications for networking; Packet switching, Store-and-Forward operation; Layered network architecture (OSI Model), Overview of TCP/IP model

Data Link Layer: Error detection: Parity checks, Internet Checksum and Cyclic redundancy check, Flow control and ARQ strategies, HDLC protocol, Media Access Control (MAC): Pure and Slotted ALOHA, IEEE 802.3 Ethernet MAC (CSMA/CD), IEEE 802.11 WiFi MAC (CSMA/CA)

Network Layer: Router Architecture, Routing and Forwarding, Routing Algorithms (Link state and Distance vector); Internet Routing protocols (RIP, OSPF and BGP); IPv4 protocol: Packet format, Addressing, CIDR, Subnetting, Fragmentation and reassembly, DHCP, NAT; IPv6 protocol summary.

Queuing Theory: Little's theorem, Simple queuing models, M/M/1 Queues, M/G/1/ Queues, queues with blocking, priority queues, vacation systems.

Transport Layer: Connectionless transport and UDP protocol, Connection-oriented transport and TCP protocol, Reliable stream service, TCP congestion control.

Application Layer Protocols: Web and HTTP, electronic mail (SMTP), file transfer protocol (FTP), Domain Name Service (DNS).

Network Security: Principles of Cryptography: Public Key Encryption (RSA Algorithm); Message Integrity and Digital Signatures, Securing TCP Connections: SSL, Network-Layer Security: IPsec and Virtual Private Networks, IEEE 802.11 WEP protocol.

Textbooks:

1. J.F. Kurose and K. W. Ross: Computer Networking, A Top-Down Approach, 8th edition, Pearson, 2021.
2. Behrouza A. Forouzan, Data Communications and Networking, 5th Edition, McGraw-Hill Education, 2012.

3. D. Bertsekas and R. Gallagar, Data Networks, 2nd Edition, PHI, 1992.
4. A. S. Tanenbaum, Computer Networks, 6th edition, Pearson, 2021.
5. A. Leon-Garcia and I. Widjaja: Communication Networks, 2/e, McGraw Hill, 2004.
6. Douglas E Comer, Computer Networks and Internet, 6th Edition, Pearson Education Asia, 2015.
7. W. Stallings, Data and Computer Communication, 10/e, Pearson Education, 2014.

EC3131	Information Theory & Coding	DEC	3-0-0	3 Credits

Pre-requisites: EC1051- Probability Theory and Random Processes

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

CO1	Acquire knowledge about information and entropy.
CO2	Analyze source-coding and channel-coding techniques
CO3	Specify specific error detecting and error correcting codes in a precise mathematical manner.
CO4	Develop and execute encoding and decoding algorithms associated with the major classes of error detecting and error correcting codes.

Detailed Syllabus:

INFORMATION THEORY: Uncertainty, Information & Entropy, Source coding theorem, The kraft inequality, Huffman coding, Shannon-Fano coding, variable-length coding, Discrete memory-less channels, Channel representation, channel matrix, Types of channels- lossless, deterministic, noise less, binary symmetric channel.
CHANNEL CAPACITY: Mutual information, Channel capacity, Shannon Hartley law, channel coding theorem, differential entropy, mutual information for continuous ensembles, channel capacity theorem. **LINEAR BLOCK CODES:** Introduction to error correcting codes, basic definitions, A Prelude, Galois Field- addition and multiplication tables, Matrix Description of Linear block Codes, Equivalent codes, The Parity Check Matrix, decoding of linear block codes, syndrome decoding, The Standard Array, Error probability after coding, Perfect codes, Hamming codes.

CYCLIC CODES: Introduction to Cyclic codes, Polynomials, Algebraic description of Cyclic codes, The Division algorithm for polynomials, a method for generating cyclic codes, Matrix description of cyclic codes, Systematic and non-systematic encoding and parity check matrix, Systematic Encoding using generator polynomial and parity check polynomial, Syndrome Decoding.

CONVOLUTIONAL CODES: Introduction to Convolutional codes, Tree codes and Trellis codes, Polynomial description of Convolutional codes (analytical representation), Distance notions for Convolutional codes, Matrix description of Convolutional codes, Viterbi decoding.

Textbooks:

1. S. Haykin, Digital Communications, John Wiley & Sons, 2009.
2. John G.Proakis, Digital Communications, 5th edition, McGraw Hill, 2007.
3. Shulin/ Daniel J.Costello Jr., Error Control Coding, Prentice Hall series in computer applications in electrical engineering series (2/e) 2005.
4. B.P. Lathi, Modern Digital & Analog Communications Systems, 5th Edition, Oxford University Press, 2018.
5. R Bose, Information Theory, Coding and Cryptography, 3rd Edition, Mc Graw Hill India 2016.
6. Todd K. Moon, Error Correction coding, John Wiley, 2005.
7. S Gravano, Introduction to Error Control Codes, Oxford University Press 2007
8. Amitabha Bhattacharya, Digital Communication, TMH 2006
9. Fred Halsall, Multidedia Communications: Applications, Networks, Protocols and Standards, Perason Education Asia, 2002.

EC3141	Digital Signal Processors	DEC	3 – 0 – 0	3 Credits

Pre-requisites: Digital Signal Processing

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

CO1	Understand the architecture and design principles of Digital Signal Processors
CO2	Learn programming techniques for DSPs using assembly and high-level languages.
CO3	Gain hands-on experience with DSP development tools and hardware.
CO4	Explore real-world applications of DSPs in areas such as audio processing, and image processing.

Detailed Syllabus:

Introduction to Digital Signal Processors: Overview of DSPs and their importance, comparison between General-Purpose Processors (GPPs) and Digital Signal Processors (DSPs), Applications of DSPs in multimedia, communications biomedical fields

DSP Architecture: Harvard vs. Von Neumann architecture; Hardware Units: Multiplier and Accumulator, Shifters, Address Generators; **Pipelining** and parallelism in DSPs; Fixed-point vs. Floating-point DSPs; Memory architecture: On-chip vs. Off-chip memory, Cache organization; Overview of popular DSPs families (e.g., Texas Instruments TMS320C5x, TMS320C6x, Analog Devices SHARC), Freescale and ARM-based DSP solutions, DSP co-processors in modern SoCs (e.g., Qualcomm Hexagon)

Instruction Set and Programming of DSPs: DSP instruction sets: Multiply-Accumulate (MAC), circular addressing, bit-reversed addressing; Assembly language programming for DSPs;

Optimization techniques for DSP programming; Introduction to DSP development environments (e.g., Code Composer Studio, MATLAB); Simulators and emulators; Writing efficient C code for DSPs, Compiler optimizations and intrinsic functions, Mixing C and assembly code

Digital Signal Processing Applications on DSPs: Audio Processing: Speech coding, noise reduction, and equalization; **Image and video Processing:** Image filtering and enhancement, Video compression techniques (e.g., MPEG, H.264);

Textbooks:

1. B. Venkataramani and M. Bhaskar, Digital Signal Processors, Architecture, Programming and Application, 2nd Edition, TMH, 2011
2. Li Tan, Digital Signal Processing: Fundamentals and application, Elsevier Inc.
3. Sen M Kuo, Bob H Lee, Wenshun Tian, Real time digital signal processing applications, John Wiley & Sons Ltd

EC3151	**Optical Communications**	**DEC**	**3–0–0**	**3 Credits**

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

CO1	Identify and characterize different components of an Optical Fiber Communication link.
CO2	Analyze optical source, Fiber and Detector operational parameters
CO3	Compute optical fiber link design parameters
CO4	Understand WDM, Optical Amplifiers, Optical Switching and networking technology concepts.

Detailed Syllabus:

Motivation for optical communications, advantages of optical fibers, optical bands, optical multiplexing standard, key elements of optical fiber communication link. Optical windows, standards, fiber types, rays and modes, ray optics, Numerical aperture, optical fiber modes, mode cutoff condition, wave equation in SI fibers, modes in SI fibers, Single mode fibers, graded index fibers. Fiber materials, fiber fabrication, Fiber optic cables.

Attenuation in fibers, absorption and scattering losses, bending losses, chromatic dispersion, modal delay, group delay, material dispersion, signal distortion in SM fibers, cutoff wavelength, mode field diameter.

LED structures, light source materials, quantum efficiency and LED power, modulation of LED, exercise problems. Laser diode, structure, modes and threshold conditions, single mode lasers, modulation of laser diodes, external modulation, linearity, exercise problems.

Source to fiber power launching, lensing schemes, fiber to fiber joints, fiber splicing, fiber connectors, exercise problems. Photo diode principles, Avalanche photodiode, photo detector noise, detector response time, structures for APD, exercise problems.

Optical receiver operation, error sources, digital receiver performance, receiver sensitivity, eye pattern features, coherent detection. WDM overviews, operational principles, WDM standards.

Textbooks:

1. Gerd Keiser, Optical Fiber Communications, TMH India, Fourth Edition, 2010.
2. Senior John M., Optical Fiber Communications, Pearson Education India, Third Edition, 2009.
3. Olivier Bouchet, HerveSizun, Christian Boisrobert and Frederique De Forne, “Free-Space Optics: Propagation and Communication”, John Wiley and Sons, 2010.

EC3161	**Artificial Intelligence**	**DEC**	**3–0–0**	**3 Credits**

Prerequisites: Data structures and Applications (CS2101)

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

CO1	Understand and explain the foundational concepts, scope, and motivations behind Artificial Intelligence.
CO2	Apply state space and heuristic search techniques for automated problem-solving and game-tree exploration.
CO3	Represent knowledge using propositional and predicate logic, and solve problems using logical deduction and resolution.
CO4	Formulate and solve planning problems using state space, plan space, and partial order planning algorithms.
CO5	Apply probabilistic and fuzzy logic-based reasoning techniques for handling uncertainty in AI systems.

Detailed Syllabus:

INTRODUCTION TO ARTIFICIAL INTELLIGENCE:

Definition of AI : The Turing Test approach, The cognitive modeling approach, The "laws of thought" approach, The rational agent approach, The Foundations of Artificial Intelligence: Philosophy, Mathematics, Economics, Neuroscience, Psychology, Computer engineering, Control theory and Cybernetics, Linguistics, The History of Artificial Intelligence : The gestation of artificial intelligence, The birth of artificial intelligence, Early enthusiasm, great expectations, Knowledge-based systems, A1 becomes an industry, The return of neural networks, A1 becomes a science, The emergence of intelligent agents.

AUTOMATED PROBLEM SOLVING

Uninformed Search Strategies: Breadth-first search, Depth-first search, Depth-limited search, Bidirectional search, informed (Heuristic) Search Strategies: Greedy best-first search, A* search, Memory-bounded heuristic search, Local Search Algorithms and Optimization Problems: Hill-climbing search, Simulated annealing search, Local beam search, Genetic algorithms, Constraint Satisfaction Problems: Backtracking Search for CSPs, Adversarial Search: Optimal Decisions in Games, Alpha-Beta Pruning,

KNOWLEDGE AND REASONING

First-Order Logic: Syntax and Semantics of First-Order Logic, Assertions and queries in first-order logic, Knowledge Engineering in First-Order Logic, Inference in First-Order Logic: Propositional vs. First-Order Inference, Resolution.

PLANNING

Planning with State-Space Search: Forward state-space search, Backward state-space search, Heuristics for state-space search, Partial-Order Planning: A partial-order planning example, Partial-order planning with unbound variables, Heuristics for partial-order planning, Planning Graphs: Planning graphs for heuristic estimation, The GRAPHPLAN algorithm.

REASONING UNDER UNCERTAINITY

Probabilistic Reasoning: Representing Knowledge in an Uncertain Domain, The Semantics of Bayesian Networks, Exact Inference in Bayesian Networks, Approximate Inference in Bayesian Networks, Extending Probability to First-Order Representations, Other Approaches to Uncertain Reasoning: Rule-based methods for uncertain reasoning, representing ignorance: Dempster-Shafer theory, Representing vagueness: Fuzzy sets and fuzzy logic.

Textbooks:

1. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, Pearson, 4th Edition, 2020.
2. Nils J. Nilsson, Artificial Intelligence: A New Synthesis, Morgan-Kaufmann, 1998.
3. Judea Pearl, Heuristics: Intelligent Search Strategies for Computer Problem Solving, Addison-Wesley Publishing Company, 1984.
4. Biere, A., Heule, M., Van Maaren, H., Walsh, T., Handbook of Satisfiability, IOS Press, 2009.

EC3171	**Pattern Recognition**	**DEC**	**3–0–0**	**3 Credits**

Prerequisites: Matrices, Real and Complex Variables, (MA2041), Probability Theory and Random Processes (EC1051)

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

CO1	Understand the supervised learning algorithms for regression and classification, and analyze models.

CO2	Apply unsupervised learning techniques for clustering, dimensionality reduction, and interpret their results in real-world contexts.
CO3	Analyze and design artificial neural networks and deep learning architectures such as CNNs, RNNs, and Transformers for complex data-driven tasks.

Detailed Syllabus:

SUPERVISED LEARNING:

Linear Models for Regression: Linear Basis Function Models, Classifiers Based on Bayes Decision Theory: Bayes Decision Theory, Minimizing the Classification Error Probability, Discriminant Functions and Decision Surfaces, Bayesian Classification For Normal Distributions, The Naive-Bayes Classifier, The Nearest Neighbor Rule, Linear Classifiers: Least Squares Methods, The Bias–Variance Dilemma, Logistic Discrimination, Support Vector Machines, The Perceptron Algorithm, Nonlinear Classifiers: Support Vector Machines: The Nonlinear Case, Decision Trees: Splitting Criterion, Stop-Splitting Rule, Class Assignment Rule, Combining Classifiers: Arithmetic Average Rule, Majority Voting Rule.

UNSUPERVISED LEARNING:

Clustering: Proximity Measures between Two Points, Hierarchical Clustering: Agglomerative Algorithms Based on Matrix Theory, Monotonicity and Crossover, Clustering Schemes: Based on Function Optimization: Mixture Decomposition, Fuzzy clustering, K-means clustering, Component Analysis: Principal component analysis, Independent component analysis, EM algorithm.

NEURAL NETWORKS:

The XOR problem, The two-layer perceptron, The backpropagation algorithm, Variants of gradient descent scheme, The loss function choice and softmax activation function, RELU activation function, Regularization and dropout, Batch normalization, Deep Learning: Convolutional Neural Networks: AlexNet, ResNet, VGG Net, GoogleNet, DenseNet Recurrent Neural Networks: LSTM, GRU, Attention mechanism, Generative Adversarial Networks, Capsule Networks.

Textbooks:

1. Theodoridis, Sergios, and Konstantinos Koutroumbas. Pattern recognition. Elsevier, 2006.
2. Duda, Richard O., and Peter E. Hart. Pattern classification. John Wiley & Sons, 2006.
3. Tom Mitchell, Machine Learning. McGraw-Hill, 1997.
4. Bishop CM, Nasrabadi NM. Pattern recognition and machine learning. New York: springer; 2006 Aug 17.

EC4111	**Digital Image Processing**	**DEC**	**3–0–0**	**3 Credits**

Prerequisites: Digital Signal Processing (EC2021)

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

CO1	Understand the fundamental concepts of digital image processing.
CO2	Apply various image enhancement techniques in spatial and frequency domains.
CO3	Implement image restoration techniques to recover degraded images.
CO5	Utilize image compression techniques for efficient storage and transmission.
CO4	Analyze different image segmentation and region-based techniques

Detailed Syllabus:

INTRODUCTION TO DIGITAL IMAGE PROCESSING:

Digital Image Fundamentals: Elements of Visual Perception, Image sensing and acquisition, Image Sampling and Quantization, Basic Relationships between Pixels, Mathematical Tools Used in Digital Image Processing.

IMAGE ENHANCEMENT IN SPATIAL AND FREQUENCY DOMAIN

Intensity Transformations: Image Negatives, Log Transformations, Power-Law (Gamma) Transformations, Piecewise-Linear Transformation Functions, Histogram Processing: Histogram Equalization, Histogram Matching (Specification), Spatial Filtering: Smoothing Linear Filters, Order-Statistic (Nonlinear) Filters, First-Order Derivatives for Image Sharpening, Second Derivative for Image Sharpening, Image smoothing and sharpening using frequency domain filters: Ideal Filters, Butterworth Filters, Gaussian Filters, Band reject and Bandpass Filters.

IMAGE RESTORATION AND NOISE REMOVAL:

Noise Models: Spatial and Frequency Properties of Noise, Some Important Noise Probability Density Functions, Periodic Noise, Estimation of Noise Parameters, Estimating the Degradation Function: Estimation by Image Observation, Estimation by Experimentation, Estimation by Modeling, Inverse filtering, Minimum Mean Square Error (Wiener) Filtering, Constrained Least Squares Filtering.

IMAGE COMPRESSION TECHNIQUES:

Fundamentals: Coding Redundancy, Spatial and Temporal Redundancy, Irrelevant Information, Measuring Image Information, Fidelity Criteria, Image Compression Models, Image Formats, Containers, and Compression Standards, Basic Compression Methods: Block Transform Coding, Predictive Coding.

IMAGE SEGMENTATION:

Point, Line, and Edge Detection: Detection of Isolated Points, Line Detection, Basic Edge Detection, Edge Linking and Boundary Detection, Thresholding: Basic Global Thresholding, Optimum Global Thresholding Using Otsu's Method, Region-Based Segmentation: Region Growing, Region Splitting and Merging,

Textbooks:

1. Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing, Pearson, 4th Edition, 2018.
2. Anil K. Jain, Fundamentals of Digital Image Processing, Prentice-Hall, 1989.
3. Rafael C. Gonzalez, Richard E. Woods, Steven Eddins, Digital Image Processing Using MATLAB, Pearson, 2nd Edition, 2009.
4. Milan Sonka, Vaclav Hlavac, Roger Boyle, Image Processing, Analysis, and Machine Vision, Cengage Learning, 4th Edition, 2014.

EC4121	**Speech Processing**	**DEC**	**3–0–0**	**3 Credits**

Prerequisites: Digital Signal Processing (EC2021)

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

CO1	Understand the anatomy and physiology involved in human speech production and classify different types of speech sounds
CO2	Apply time-domain signal processing techniques such as all-pole modeling and linear prediction for the analysis and synthesis of speech signals.
CO3	Analyze and modify speech signals using short-time Fourier transform, filter bank summation, and overlap-add methods
CO4	Understand the speaker recognition techniques using spectral and non-spectral features using GMM, vector quantization, and minimum-distance classifiers.

Detailed Syllabus:

PRODUCTION AND CLASSIFICATION OF SPEECH SOUNDS

Anatomy and Physiology of Speech Production: Lungs, Larynx, Vocal tract, Categorization of Sound by Source, Spectrographic Analysis of Speech, Categorization of Speech Sounds: Elements of a Language, Vowels, Nasals, Fricatives, Plosives, Transitional Speech Sounds, Prosody: The Melody of Speech.

TIME-DOMAIN ANALYSIS

All-Pole Modelling of Deterministic Signals: Formulation, Error Minimization, Autocorrelation method, The Levinson Recursion and Its Associated Properties, Lattice Filter Formulation of the

Inverse Filter, Linear Prediction Analysis of Stochastic Speech Sounds, Synthesis Based on All-Pole Modelling, Homomorphic Signal Processing: Homomorphic Systems for Convolution,

FOURIER TRANSFORM ANALYSIS AND SYNTHESIS

Short-Time Analysis: Fourier Transform View, Filtering View, Time-Frequency Resolution Trade-offs, Short-Time Synthesis: Filter Bank Summation (FBS) Method, Overlap-Add (OLA) Method, Time-Frequency Sampling, Time-Scale Modification and Enhancement of Speech: Time-Scale Modification, Noise Reduction

SPEAKER RECOGNITION

Spectral Features for Speaker Recognition: Mel-Cepstrum, Sub-Cepstrum, Speaker Recognition Algorithms: Minimum-Distance Classifier, Vector Quantization, Gaussian Mixture Model (GMM), Non-Spectral Features in Speaker Recognition: Glottal Flow Derivative, Source Onset Timing, Relative Influence of Source, Spectrum, and Prosody.

Textbooks:

1. Quatieri, Thomas F. Discrete-time speech signal processing: principles and practice. Pearson Education India, 2002.
2. Rabiner, L. R., & Schafer, R. W. (2007). Introduction to digital speech processing. Foundations and Trends® in Signal Processing, 1(1–2), 1-194.
3. Jurafsky, Dan. Speech & language processing. Pearson Education India, 2000.
4. Benesty J, Sondhi MM, Huang Y, editors. Springer handbook of speech processing. Berlin: springer; 2008 Dec.
5. Gold, Ben, Nelson Morgan, and Dan Ellis. Speech and audio signal processing: processing and perception of speech and music. John Wiley & Sons, 2011.

EC4131	**Introduction to Quantum Communications**	**DEC**	**3–0–0**	**3 Credits**

Prerequisites: None

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

CO1	The basics of Quantization of EM Waves and Quantum Optics
CO2	The basics of entangled particles generation.
CO3	The basics of linear optics and single photon based concepts
CO4	The central ideas in Quantum Cryptography**.**

Detailed Syllabus:

Revision of quantum mechanics and Dirac Notations, No cloning theorem, Quantum Key Distribution protocols, BB84, E91, BBM92, B92, COW, DPS.

Twin-photon generation with non-linear interactions, parametric generation of light, spontaneous parametric down-conversion, optical parametric amplifiers and optical parametric oscillator.

Single and two photon interference, Hanbury-Brown-Twiss experiment, Photonbunching and anti-bunching, EinsteinPodolsky-Rosen (EPR) Paradox, Entangled State, Bell's Inequality.

Entanglement and Bell Theorems, Bell Measurements and Tests

Theory of photodetection, direct, balanced, and homodyne detection

Quantum Memories, Quantum repeaters, Quantum Teleportation protocol, Quantum Dense coding

Textbooks:

1. Nielsen and Chuang, Quantum computation and quantum information, Cambridge University Press, Cambridge (2010)
2. A Pathak, Elements of Quantum Computation and Quantum Communication, Boca Raton, CRC Press (2015)
3. Gisin, Nicolas, et al. Quantum cryptography, Reviews of modern physics 74.1 (2002): 145
4. Christopher Gerry and Peter Knight, Introductory Quantum Optics, Cambridge University Press (2004)
5. Mark Fox, Quantum Optics: An introduction, Oxford University Publishers (2006)

EC4141	**Advanced Wireless Communications: 5G and beyond**	**DEC**	**3-0-0**	**3 credits**

Prerequisites:

Wireless Communications: EC4051

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

CO1	Understand 5G cellular standard architecture and key capabilities
CO2	Understand the key enabling technologies for 5G Physical layer (New Radio Interface)
CO3	Understand the key enabling technologies for next generation (5G and beyond) wireless standards
CO4	do system level simulation and performance evaluation of physical layer algorithms for 5G and beyond wireless systems
CO5	apply machine/deep learning in next generation wireless communication

Detailed Syllabus:

Coding for Wireless Communications: Space-time block codes: V-blast and D-blast, Polar codes

Key 5G Technologies : Evolution of cellular communications from 1G to 5G, NOMA (Non orthogonal multiple access) , Massive MIMO Systems: motivation and system model, advantages and challenges, uplink and downlink transmission, spectral and energy efficiency, cell free massive MIMO systems, Millimeter wave Communication: mm Wave channel modelling, advantages and challenges, mm Wave channel estimation and beamforming, Cooperative and full duplex communication systems.

Key 6G Technologies : Tera Hertz communications: channel modeling and challenges, Near field communications, Intelligent Reflective surfaces, Integrated sensing and communication: waveform design issues, beamforming.

Machine Learning for Wireless Communication: Overview of ML model, Data set generation and acquisition for wireless communication, Application examples of ML in wireless communication physical layer algorithm design e.g. modulation design, massive MIMO channel estimation, MIMO receiver design etc.,

Textbooks:

1. T. Marzetta, E. Larsson, H. Yang, and H Ngo, “Fundamentals of Massive MIMO. Cambridge”, Cambridge University Press, 2016.
2. Eric dahlman et al., 5G NR, The Next generaton Wireless access technolgy, Academic Press, 2021.
3. Ali Zaidi et al., 5G Physical layer, Principles, Models and Technolgy Components, Academic Press, 2018.
4. Theodore S.Rappaport, Robert W.Heath, Robert C.Danials, James N.Murdock “Millimeter Wave Wireless Communications”, Prentice Hall Communications.
5. E. Björnson, J. Hoydis and L. Sanguinetti, “Massive MIMO Networks: Spectral, Energy, and Hardware Efficiency”, Foundations and Trends in Signal Processing: Vol. 11, No. 3-4, pp 154–655, (2017).
6. D. Tse and P. Viswanath, “Fundamentals of Wireless Communication”, Cambridge university press, 2nd Edition, 2005.
7. Andea Goldsmith, Wireless Communications, 2005, Cambridge University Press.

EC4151	Neural Networks for Communications and Signal Processing	3–0–0	3 Credits

Prerequisites: EC4051 Wireless communications, EC2021 Digital Signal Processing

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

CO1	Understanding different types of Neural Networks useful for various signal processing and communication applications
CO2	Analyze real-world datasets to solve problems in speech and communication domain and custom dataset generation
CO3	Design and implement neural network models to solve problems in signal processing and communication
CO4	Evaluate the performance of neural network models (accuracy, latency, robustness in signal processing and wireless communication scenarios.

Detailed Syllabus:

Introduction to Neural Networks: Supervised and Unsupervised learning, Classification, and regression problems, Deep Feed Forward Networks: Architecture, Activation Functions; Training a deep network: Gradient based Learning, Basic Algorithms, Evaluation metrics; Regularization for Neural Networks: Concept of generalization, Underfitting, Overfitting, Bias, Variance Regularization techniques, Early stopping and Dropout; Convolutional Neural Networks: Motivation, Architecture and Training, Sequence Modeling: Recurrent and Recursive Neural Networks

Applications in Speech and Audio Processing: Feature Extraction: MFCC, STFT and Spectrogram; Applications including Text-to-speech synthesis, Speech enhancement and noise reduction, Automatic speech recognition, Emotion recognition from speech and Audio Classification.

Applications in Communication: Related Data Sets (RML2016.10a, RML2018, Cost 2100, Deep MIMO), Custom dataset generation techniques, Applications of machine learning in communication: Automatic Modulation Classification, Channel Estimation and Equalization, in MIMO systems, Beamforming and Receiver design in Massive MIMO Systems, PAPR reduction and CFO estimation in OFDM systems, Resource allocation in NOMA systems; Federated Learning in Wireless communication.

Text Books:

1. Ian Goodfellow and Yoshua Bengio and Aaron Courville, A Deep Learning, MIT Press, 2016.
2. Pattern Recognition and Machine Learning, C. M. Bishop, Second Edition, Springer, 2011.
3. Kevin P Murphy, Machine Learning - A Probabilistic Perspective, MIT Press 2012.
4. L. Rabiner, and H Juang, Fundamentals of Speech Recognition, Prentice Hall, 1993.
5. Yonina C. Eldar, et al, Machine Learning and Wireless Communications, Cambridge University Press (2022)

EC4161	**Satellite Communications**	**DEC**	**3 – 0 – 0**	**3 Credits**

Pre-requisites: Digital Communications, Electromagnetic waves and propagation

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

CO1	Understand the fundamentals of satellite communication systems.
CO2	Learn about satellite orbits, link design, and modulation techniques.
CO3	Explore the architecture and components of satellite systems.
CO4	Analyze real-world applications and emerging trends in satellite communications.

Detailed Syllabus:

Introduction to Satellite Communications: Overview of satellite communication systems, History and evolution of satellite technology, Advantages & Applications of Satellite Communications, Basic Concepts: Frequency Bands (L, C, Ku, Ka), Orbits, and Coverage

Orbital Mechanics & satellite orbits: Kepler's Laws of Planetary Motion, Satellite Orbits: LEO, MEO, GEO, HEO; Orbital Elements & Calculations, Launch Vehicles & Space Debris, Geostationary vs. Non-Geostationary Satellites.

Satellite Subsystems: Space Segment: Antennas, Transponders, Power, Thermal Control; Ground Segment: Earth Stations, VSATs, Telemetry & Control; Onboard Processing & Regenerative Satellites, Satellite Bus vs. Payload;

Satellite Link Design: Basic Link Budget Equation, Uplink & Downlink Power Calculations, transmit power, pathloss, EIRP, Noise and interference in satellite links, Carrier-to-noise ratio (C/N) and signal-to-noise ratio (SNR), Atmospheric & Rain Attenuation

Satellite Communication Networks & Standards: VSAT Networks & Applications, Satellite Internet & IP Networking, DVB-S, DVB-S2, DVB-RCS Standards, Mobile Satellite Services (Inmarsat, Iridium, Thuraya), Role of Satellites in 5G & Future Communications.

Emerging Trends & Applications: High Throughput Satellites (HTS), LEO & MEO Constellations (Starlink, OneWeb, Kuiper), Internet of Things (IoT) via Satellites, AI & Machine Learning in Satellite Communications

Text books:

1. Timothy Pratt, Charles Bostian, and Jeremy Allnutt , Satellite Communications
2. Gerard Maral and Michel Bousquet , Satellite Communication Systems
3. Gary D. Gordon and Walter L. Morgan, Principles of Satellite Communications

Department Electives: Electronics Stream

EC3211	Computer Architecture and Organization	DEC	3–0–0	3 Credits

Prerequisites: EC1031 Digital System Design

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

CO1	Identify functional units, bus structure and addressing modes.
CO2	Design the hardwired and micro-programmed control units.
CO3	Identify memory hierarchy and performance.
CO4	Design Arithmetic Logic Unit.
CO5	Interface I/O devices.

Detailed Syllabus:

Basic Structures of Computers: Computer Types, Functional Units, Basic Operational Concepts, Bus Structures, Software, Performance, Multiprocessors and multicomputer, Historical Perspective.

Machine instructions and Programs: Numbers, Arithmetic Operations and Characters, Memory Locations and Addresses, Memory Operations, Instructions and Instruction Sequencing, Addressing Modes.

Input/output Organization: Accessing I/O Devices, Interrupts, Processor Examples, Direct Memory Access, Buses, Interface Circuits, Standard I/O Interfaces.

The Memory System: Some Basic Concepts, Semiconductor RAM Memories, Read Only Memories, Speed Size and Cost, Cache Memories, Virtual Memories, Memory Management Requirements, Secondary Storage.

Arithmetic: Addition and Subtraction of Signed Numbers, Design of Fast Adders, Multiplication of Positive Numbers, Signed-Operand Multiplication, Fast Multiplication, Integer Division, Floating Point Numbers and Operations, Implementing Floating Point Operations.

Basic Processing Unit: Some Fundamental Concepts, Execution of Complete Instruction, Multiple-Bus Organization, Hardwired Control, Micro programmed Control.

Pipelining: Basic Concepts, Data Hazards, Instruction Hazards, Influence on Instruction Sets, Data Path and Control Considerations, Super Scalar Operations.

Large Computer Systems: Forms of Parallel Processing, Array Processors, the Structure of General-Purpose Multiprocessors, Interconnection Networks.

Textbooks:

1. Carl Hamacher, Computer Organization, 5th Edition, McGraw Hill Publishers, 2002.

2. William Stallings, Computer Organization and Architecture Designing for Performance, 8th Edition, Pearson Education, 2010.

3. John P Hayes, Computer Architecture and Organization, 3rd revised Ed., McGraw-Hill, 1998.

EC3221	Electronic Instrumentation	DEC	3–0–0	3 Credits

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

CO1	Understand and estimate errors in a measurement system.
CO2	Identify the instrument suitable for specific measurements.
CO3	Estimate accurately the values of R, L and C employing suitable bridges.
CO4	Understand the basic principles of transducers for displacement, velocity, temperature and pressure.
CO5	Operate special measuring instruments such as Wave Analyzer, Harmonic Distortion Analyzer and Spectrum Analyzer.
CO6	Identify data acquisition system for a specific application.

Detailed Syllabus:

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

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

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

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

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

Textbooks:

1. Oliver and Cage, Electronic Measurements and Instrumentation, by McGraw Hill, 2017.
2. W.D.Cooper Felbrigg, Electronic Instrumentation & Measurement techniques, PHI, 1990.
3. D.A. Bell, Reston, Electronic Instrumentation and Measurements, 2013, 3rd Edition.
4. H.S. Kalsi, Electronic Instrumentation, McGraw Hill, 2017, 3rdEdition.

EC3231	Nanoelectronics: Devices and Emerging Technologies	PCC	3-0-0	3 Credits

Prerequisites: EC1011 Electronic Devices and Circuits

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

CO1	Understand the principles of CMOS scaling and the resulting short-channel effects.
CO2	Learn advanced design techniques, including high-k dielectrics, metal gates, and source/drain engineering.
CO3	Perform MOSFET parameter extraction through C-V and I-V electrical characterization.
CO4	Analyze non-classical MOSFET structures and carrier transport mechanisms like ballistic transport and velocity saturation.

Detail Syllabus

CMOS Technology Scaling issues

Introduction to Nanoelectronics, CMOS Scaling, Short channel Effects (SCE), Subthreshold Conduction, Drain Induced Barrier Lowering (DIBL)

Design Techniques for Nanoscale Transistors

Channel and Source/Drain Engineering, CMOS process Flow, Gate oxide scaling and reliability, High-k Gate dielectrics, Metal gate transistor, Industrial CMOS Technology

Electrical Characterization of MOS Devices

Ideal MOS C-V Characteristics, Effect of non-idealities on C-V, MOS Parameter Extraction from C-V Characteristics, MOS Parameter Extraction from I-V Characteristics

Non Classical MOSFETs: Overview and Carrier Transport in Nano MOSFETs

MOSFET Analysis, sub-threshold swing “S”, Interface state density effects on “S”. Short Channel Effects (SCE) and Drain Induced Barrier Lowering (DIBL), Velocity Saturation, Ballistic transport, and Velocity Overshoot Effects and Injection Velocity

Silicon On Insulator (SOI) MOSFET

SOI Technology and comparisons with Bulk Silicon CMOS technology, SOI MOSFET structure, Partial Depleted (PD) and Fully Depleted (FD) SOIMOSFETs, FD SOI MOSFET: Operation Modes and Threshold Voltages and Electric Fields, Sub-threshold Slope & SCE suppression in FD SOI MOSFET, Volume Inversion and Ultra thin (UTFD) SOI MOSFET and quantization Effect, FINFET

Metal-Semiconductor Contacts and Metal-Source/Drain Junction MOSFETs

Need for MS contact Source/Drain Junction in Nano scale MOSFETs, Rectifying and Ohmic contacts and challenges in MS junction source drain MOSFET Technology, Effect of Interface states and Fermi level pinning on MS contacts on Si and passivation techniques for MS S/D MOSFETs

Textbooks:

1. Taur, Y. and Ning, T.H., 2021. Fundamentals of modern VLSI devices. Cambridge university press.
2. Colinge, J.P. ed., 2008. FinFETs and other multi-gate transistors (Vol. 73, p. 23). New York: springer.
3. Sze, S.M., 2008. Semiconductor devices: physics and technology. John wiley & sons.

EC3241	**Embedded Systems Design**	**DEC**	**3–0–0**	**3 Credits**

Prerequisites: EC2031 Microprocessors and Microcontrollers

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

CO1	Identify the applications, Design metrics and challenges of Embedded system
CO2	Identify hardware components and their functions in embedded system design.
CO3	Develop embedded software using compilers, IDEs, and debugging tools.
CO4	Apply computational models for designing embedded applications.
CO5	Understand RTOS concepts and analyze task scheduling and inter-process communication.

Detailed Syllabus:
Introduction to Embedded Systems: Embedded systems Overview, Embedded Systems vs General Computing Systems, History of Embedded Systems, Classification, Major Application Areas, Embedded product development cycle, Purpose of Embedded Systems, Characteristics of embedded computing applications, Design Challenges, Common Design Metrics.
Embedded System Development:
Hardware: General Purpose and Domain Specific Processors, Microcontroller architectures (RISC, CISC), ASICs, PLDs, Commercial Off the Shelf Components (COTS), Memory: ROM, RAM, Memory according to the type of Interface, Memory Shadowing, Memory selection for Embedded Systems, Sensors and Actuators, Reset Circuit, Brown-out Protection Circuit, Oscillator Unit, Real Time Clock, Watchdog Timer, Communication Interface: Onboard and External, Communication Interfaces.
Software Development: Cross assemblers/compilers, Compiler Tool chains – GCC and ARM, Device Driver, Firmware, Middleware - Debugging tools: Emulators, Simulators, In-Circuit Debuggers, Logic Analyzer, Integrated Development Environment (IDE).
Computational Models in Embedded Design: Data Flow Graph Model, Control Data Flow Graph, State Machine Model, Sequential Program Model, Concurrent/Communicating Process Model. Unified Modelling Language.
Embedded Real –Time Operating Systems: Introduction to basic concepts of RTOS- Task, process & threads, Multiprocessing and Multitasking, Scheduling algorithms, Semaphores, Mutex,

Mailboxes, Message queues, Event Registers, Pipes, Signals, Timers, Memory management, Priority Inversion problem.

Textbooks:

1. K.V Shibu, Introduction to Embedded Systems, Mc Graw Hill India, second edition, 2016.
2. Embedded Systems Design –Santanu Chattopadhyay, PHI, 2013.
3. Embedded System Design -Frank Vahid, Tony Givargis, John Wiley
4. Tianhong Pan and YI Zhu, Designing Enbedded System with Arduino: A Fundamental Technology for Makers, Springer, 2017.
5. K.V.K.K. Prasad, Embedded/Real-Time Systems: Concepts Design and Programming, Dreamtech, 2005
6. Lyla B Das, Embedded Systems: An Integrated Approach, Pearson, 2013
7. David E. Simon, An Embedded Software Primer, CD-ROM Edition, Addison Wesley, 2000.

EC3251	**Fundamentals of Optoelectronic Devices**	**DEC**	**3–0–0**	**3 Credits**

Prerequisites: EC1011 Electronic Devices and Circuits

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

CO1	Understand semiconductor fundamentals for optoelectronic applications.
CO2	Analyze optical processes such as absorption, radiation, and their impact on semiconductor devices.
CO3	Understand the working principles of optoelectronic detectors, LEDs, laser diodes, and photovoltaic devices.
CO4	Evaluate performance trade-offs in optoelectronic devices for various applications.

Detailed Syllabus:

Review of Semiconductors for Optoelectronics– Energy band structures: direct and indirect bandgap semiconductors, Carrier generation and recombination mechanisms: radiative vs. non-radiative, Junction formation: PN junctions in optoelectronics, Semiconductor heterostructures: types and role in light-matter interaction

Optical Processes in Semiconductors – Absorption mechanisms including indirect intrinsic transitions, exciton absorption, impurity band absorption, and electric field effects. Radiation processes and the relationship between absorption and emission spectra, with a focus on near-bandgap radiative transitions.

Optoelectronic Detectors – Working principles and characteristics of photoconductors, junction photodiodes, PIN photodiodes, heterojunction diodes, avalanche photodiodes, phototransistors, modulated barrier photodiodes, and metal-semiconductor-metal (MSM) photodiodes.

Photovoltaic Devices – Solar energy spectrum, operation principles, I-V characteristics, equivalent circuit modeling, temperature effects, and an overview of materials, device structures, and efficiencies.

Light Emitting Diodes (LEDs) – Electroluminescence process, material selection, device structure and parameters, efficiency considerations, light output characteristics, LED structures, heterojunction LEDs, surface-emitting LEDs, and performance parameters including frequency response and modulation bandwidth.

Laser Diodes – Junction laser principles, threshold current, heterojunction and distributed feedback lasers, cleaved coupled cavity lasers, quantum well lasers, and modulation techniques. Analysis of rate equations, steady-state solutions, transient behavior, frequency response, and high-frequency modulation.

Textbooks:

1. S.M. Sze, Semiconductor Devices - Physics and Technology, Wiley, New York.
2. J. Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw Hill.
3. P. Bhattacharya, Semiconductor Optoelectronic Devices, Pearson Education.

EC3261	**Semiconductor Device Modelling**	**DEC**	**3–0–0**	**3 Credits**

Prerequisites: EC1011 Electronic Devices and Circuits

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

CO1	Understand the fundamentals of semiconductor device working
CO2	Solving Drift-Diffusion and Poisson's Equation
CO3	Understanding of simulations of semiconductor devices

Detailed Syllabus:

Semi-classical Bulk Transport – Qualitative Model, Semi-classical Bulk Transport – EM field and Transport Equations, Drift-Diffusion Transport Model – Equations, Boundary Conditions, Mobility and Generation / Recombination, Characteristic times and length, Energy band diagrams, SQEBASTIP – nine steps of deriving a device model

Types of device models, MOSFET : Device Structures and Characteristics, DC Model of a Large Uniformly Doped Bulk MOSFET: Qualitative Theory, DC Model of a Large Uniformly Doped Bulk

MOSFET: Equations, Boundary conditions, Approximations, DC Model of a Large Uniformly Doped Bulk MOSFET: Uniformly Doped Bulk MOSFET: Surface Potential and Threshold Based Solutions of IDS (VGB, VDB, VSB), DC Model of a Large Uniformly Doped Bulk MOSFET : Testing, Improvement, Parameter Extraction, Series resistance, Non-uniform doping and Small geometry effects

Textbooks:

1. Pierret, Robert F, Semiconductor device fundamentals, Pearson Education India, 1996.

2. Neamen, Donald, An introduction to semiconductor devices, McGraw-Hill, Inc., 2005.

3. Streetman, Ben G., and Sanjay Banerjee, Solid state electronic devices, Vol. 4. New Jersey: Prentice hall, 2000.

4. Prof. Karmalkar, Semiconductor Device Modelling, IIT - Madras
https://archive.nptel.ac.in/courses/117/106/117106033/

EC4211	Thin film Technology	DEC	3-0-0	3 Credits

Prerequisites: EC1011 Electronic Devices and Circuits

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

CO1	Understand the fundamentals of thin films, including their properties, historical development, and diverse applications.
CO2	Describe and compare different Physical Vapor Deposition (PVD) techniques, including evaporation and sputtering methods.
CO3	Analyze Chemical Vapor Deposition (CVD) and Atomic Layer Deposition (ALD) techniques, their mechanisms, and applications.
CO4	Evaluate thin film properties, deposition parameters, and characterization methods for optimizing film quality and performance.

Detailed Syllabus:

Introduction to Thin Films

Overview of Thin Films: Definition, historical evolution, and significance. Applications: Microelectronics, optics, solar cells, MEMS, biomedical coatings.

Key Properties of Thin Films: Thickness, uniformity, adhesion, stress, and microstructure. Metrics: Deposition rate, stoichiometry, and film quality.

Physical Vapor Deposition (PVD)

Principles of PVD: Basics of vacuum technology (pressure ranges, mean free path). Classification of PVD: Evaporation vs. Sputtering.

Evaporation Techniques: Thermal Evaporation: Resistive heating, boat sources, and applications. Limitations: Low melting point materials, poor step coverage. Electron Beam (E-beam) Evaporation: E-beam gun design, advantages (high-purity films, high melting point materials).

Sputtering Techniques

DC Sputtering: Plasma generation, target materials, and reactive sputtering.

RF Sputtering: Principle of RF power, insulator deposition.

Chemical Vapor Deposition (CVD)

Fundamentals of CVD: Thermodynamics and kinetics of CVD reactions. Types: Atmospheric Pressure CVD (APCVD), Low-Pressure CVD (LPCVD).

Metal-Organic CVD (MOCVD): Precursors (e.g., TMGa, TMIn), epitaxial growth (GaN, III-V semiconductors). Case study: LED fabrication.

Atomic Layer Deposition (ALD): Self-limiting surface reactions, monolayer growth. Applications: High-κ dielectrics (HfO_2), nanoscale coatings.

Recommended Textbooks

1. Donald L. Smith, Thin Film Deposition: Principles and Practice.
2. Krishna Seshan, Handbook of Thin Film Deposition.
3. Jong-Hee Park and T.S. Sudarshan, Chemical Vapor Deposition.
4. Milton Ohring, Materials Science of Thin Films.

EC4221	**Low power VLSI**	**DEC**	**3-0-0**	**3 Credits**

Prerequisites: EC3031 VLSI Design

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

CO1	Identify the sources of power consumption in a given VLSI Circuit.
CO2	Implement low-power design approaches for system-level and circuit-level measures
CO3	Implement logic styles for low-power logic synthesis and understand low-power design techniques.
CO4	Decide at which level of abstraction is advantageous to implement low-power techniques in a VLSI system design.

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

Supply voltage scaling approaches: Device feature size scaling, Multi-VDD Circuits, Architectural level approaches: Parallelism and Pipelining, Voltage scaling using high-level transformations, Dynamic voltage scaling, Power Management.

Switched Capacitance Minimization Approaches: Hardware Software Trade-off, Bus Encoding, Two's complement Vs Sign Magnitude, Architectural optimization, Clock Gating, Logic styles.

Memories: SRAM & DRAM: Sources of power dissipation, Low power Circuit techniques.

Leakage Power Minimization Approaches:
Variable-threshold-voltage CMOS design approach, multi-threshold-voltage CMOS Design approach, Power gating, dual-Vt assignment approach, and Transistor stacking.

Adiabatic Logic Circuits, Battery-Driven System, CAD Tools for Low Power VLSI Circuits.

Textbooks:

1. Ajit. Pal, Low power VLSI Circuits and systems, 1st Edition, Springer, 2015.
2. Anantha P. Chandrakasan and Robert W. Brodersen, Low Power Digital CMOS Design, Kluwer Academic Publishers, 1995.
3. Jan Rabaey, Low Power Design Essentials, 1st Edition, Springer, 2009.
4. Kiat Seng Yeo and Kaushik Roy, Low-Voltage, Low-Power VLSI Subsystems, Edition 2009, Tata McGraw-Hill.

EC4231	**Quantum Transport in Modern Devices**	**DEC**	**3–0–0**	**3 Credits**

Prerequisites: EC1011 Electronic Devices and Circuits

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

CO1	Understand the fundamentals of nanoelectronics, quantum mechanics, and the limitations of classical devices.
CO2	Analyze electron behavior in solids, including energy bands, density of states, and Fermi-Dirac distribution.
CO3	Understand quantum transport phenomena such as Bloch electrons, ballistic transport, and quantum resistance.
CO4	Examine quantum effects in MOSFETs, lattice dynamics, and electron-phonon interactions in nanodevices.

Detailed Syllabus:

Introduction: Trends in Nanoelectronics, Mesoscopic systems, Need for nanoelectronics: Limitations of classical devices, Quantum mechanics fundamentals

Electrons in Solids – Overview of the Drude and Sommerfeld models, quantization in k-space using periodic boundary conditions, density of states and Fermi energy, Fermi-Dirac distribution.

Crystal Properties and Electronic Structure – Basics of crystal lattices and reciprocal space, Brillouin zones, Bloch’s theorem, energy bands, electron behaviour in periodic potentials, crystal momentum, and band velocity. Bandstructure in semiconductors (Si, Ge, III-V) and its device implications.

Semiclassical Electron Dynamics and Quantum Transport – Electron dynamics in periodic potentials, including Bloch electrons and wave packets. Conductivity in a perfect crystal, energy conservation, and the role of energy bands in current conduction. Introduction to the concept of holes in semiconductors. Ballistic transport, Landauer formula, quantum resistance and conductance.

MOSFET Operation and Quantum Effects: Fundamental principles of MOSFET operation, top of the barrier concept, Quantum effects- Coupled Poisson-Schrodinger equations and iterative solutions, channel quantization, quantum capacitance, Tunneling and 1D barrier transmission.

Lattice Dynamics and Quantum Mechanical Effects – lattice vibrations in a one-dimensional atomic chain, acoustic and optical branches. Introduction to the quantum theory of linear harmonic oscillators, phonons, electron-phonon scattering. Quantum angular momentum, eigenvalues, Pauli spin matrices, spin-orbit coupling.

Textbook:

1. George. W. Hanson, Fundamentals of Nanoelectronics, Pearson Prentice Hall (2008)
2. Y. Taur and T. H. Ning, Fundamentals of Modern VLSI devices, Cambridge University Press.
3. D. J. Griffiths, Introduction of Quantum Mechanics, Prentice Hall.
4. S. M. Sze, Physics of Semiconductor devices, Wiley-Interscience.
5. John Davies, The Physics of Low-dimensional Semiconductors: An Introduction, Cambridge University Press (1997).
6. Supriyo Datta, Quantum Transport: Atom to Transistor, Cambridge University Press

EC4241	Analog VLSI Design	PCC	3-0-0	3 Credits

Prerequisites: EC3031 VLSI Design

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

CO1	Understand the concepts of Single-Stage Amplifiers Design
CO2	Understand the concepts of Differential Amplifiers
CO3	Understand the concepts of Current Mirrors
CO4	Understand the concepts of Frequency Response of Amplifiers

Single-Stage Amplifiers

Applications, General Considerations, Common-Source Stage, Common-Source Stage with Resistive Load, CS Stage with Diode-Connected Load, CS Stage with Current-Source Load, CS Stage with Active Load, CS Stage with Triode Load, CS Stage with Source Degeneration, Source Follower, Common-Gate Stage, Cascode Stage, Cascode, Choice of Device Models

Differential Amplifiers

Single-Ended and Differential Operation, Basic Differential Pair, Qualitative Analysis, Quantitative Analysis, Degenerated Differential Pair, Common-Mode Response, Differential Pair with MOS Loads Gilbert Cell.

Current Mirrors and Biasing Techniques

Current Mirrors, Cascode Current Mirrors, Active Current Mirrors, Large-Signal Analysis, Small-Signal Analysis, Common-Mode Properties, Other Properties of Five-Transistor OT, Biasing, CS Biasing, CG Biasing, Source Follower Biasing, Differential Pair Biasing

Frequency Response of Amplifiers

General Considerations, Miller Effect, Association of Poles with Nodes, Common-Source Stage, Source Followers, Common-Gate Stage, Cascode Stage, Differential Pair, Differential Pair with Passive Loads, Differential Pair with Active Load, Gain-Bandwidth Trade-Offs, One-Pole Circuits, Multi-Pole Circuits

Textbooks:

1. Behzad Razavi, Design of Analog CMOS Integrated Circuits, 2nd Edition, McGraw Hill Education, 2016.

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

3. Neil H.E. Weste and David Harris, CMOS VLSI Design: A circuits and systems perspective, 4th Edition, Pearson Education, 2015.

4. Prof. Chandorkar, Analog CMOS VLSI Design, NPTEL, IIT-Bombay, https://archive.nptel.ac.in/courses/117/101/117101105/

EC4251	**FPGA Architectures and Applications**	**DEC**	**3-0-0**	**3 Credits**

Prerequisites: Digital Logic Design

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

CO1	Acquire Knowledge about various architectures and device technologies of comprehend FPGA Architectures
CO2	Describe FSM and different FSM techniques like petrinets & different case studies
CO3	Comprehends FSM Architectures and their applications
CO4	Analyze System level Design and their application for Combinational and Sequential Circuits.

Detailed Syllabus:

Programmable Logic Devices: ROM, PLA, PAL, PLD, PGA – Features, programming and applications

Field Programmable Gate Arrays: Field Programmable Gate Arrays – Logic blocks, routing architecture, Design flow, Technology Mapping for FPGAs.
FPGA Architectures: Xilinx XC4000 & ALTERA's FLEX 8000/10000 FPGAs: AT & T – ORCA's (Optimized Reconfigurable Cell Array): ACTEL's – ACT-1, 2, 3 and their speed performance.
Finite State Machines: Top-Down Design – State Transition Table, state assignments for FPGAs. Problem of initial state assignment for one-hot encoding. Derivations of state machine charges. Realization of state machine charts with a PAL. Alternative realization for state machine chart using microprogramming. Linked state machines. One–hot state machine, Petrinets for state machines – basic concepts, properties, extended petrinets for parallel controllers.
FSM Architectures: Architectures cantered around non-registered PLDs. State machine designs, centered around shift registers. One–Hot design method. Use of ASMs in One–Hot design. Application of the One–Hot method.
System Level Design: Controller, data path and functional partitions, Parallel adder cell, parallel adder sequential circuits, counters, multiplexers, parallel controllers.

Textbooks:

1. P.K.Chan & S. Mourad, Digital Design Using Field Programmable Gate Array, prentice Hall (Pte), 1994.
2. S.Brown, R.Francis, J.Rose, Z.Vransic, Field Programmable Gate Array, Kluwer Publications, 1992.
3. J. Old Field, R.Dorf, Field Programmable Gate Arrays, John Wiley & Sons, New York, 1995.
4. S.Trimberger, Edr. Field Programmable Gate Array Technology, Kluwer Academic Publications, 1994.
5. Bob Zeidman, Designing with FPGAs & CPLDs, CMP Books, 2002.

Departmental Electives: RF and Microwave Stream

EC3311	Fundamentals of Radar Signal Processing	DEC	3–0–0	3 Credits

Pre-requisites: Signals and Systems, Probability and Statistics

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

CO1	To introduce fundamental concepts of radar signal processing and its real-world applications.
CO2	To develop a strong foundation in radar detection, estimation, and Doppler processing.
CO3	To develop the fundamentals of Synthetic Aperture Radar (SAR), SAR imaging techniques

Detailed Syllabus:

Introduction to Radar Systems: Fundamentals of radar and its applications, Radar equation and system parameters, Types of radar: CW, pulse, and modulated radar.

Radar Signals and Waveforms: Time and frequency domain representation of radar signal, Radar waveforms: pulse, linear FM (chirp), phase-coded signals, Ambiguity function and range-Doppler coupling.

Detection of Radar Signals in Noise: Noise characteristics and Signal-to-Noise Ratio (SNR), Matched filtering for signal detection, Constant False Alarm Rate (CFAR) detection techniques.

Doppler Processing and Target Detection: Doppler effect and velocity measurement, Moving Target Indication (MTI) and pulse Doppler radar, Fast Fourier Transform (FFT) for Doppler processing.

Direction Finding and Target Tracking: Introduction to Direction of Arrival (DOA) estimation, Beamforming and adaptive processing techniques, Basics of Kalman filtering for target tracking.

Advanced Radar Signal Processing Topics: Synthetic Aperture Radar (SAR) fundamentals, SAR imaging techniques and applications, Introduction to cognitive radar and AI in radar signal processing.

Textbooks:

1. M. A. Richards, J. A. Scheer, and W. A. Holm, Eds., Principles of Modern Radar: Basic Principles. Edison, NJ, USA: SciTech Publishing, 2010.
2. B. R. Mahafza, Radar Systems Analysis and Design Using MATLAB, 3rd ed. Boca Raton, FL, USA: CRC Press, 2013.
3. M. I. Skolnik, Introduction to Radar Systems, 3rd ed. New York, NY, USA: McGraw-Hill, 2001.

4. M. A. Richards, Fundamentals of Radar Signal Processing, 2nd ed. New York, NY, USA: McGraw-Hill, 2014.

Learning Resources:

1. https://archive.nptel.ac.in/courses/108/105/108105154/

EC3321	Radar Engineering	DEC	3–0–0	3 Credits

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

CO1	Understand the basic operation of pulse and CW radar systems.
CO2	Evaluate the radar performance based on pulse width, peak power and beam width.
CO3	Choose suitable tracking radar for a given problem.
CO4	Select appropriate criterion for detecting a target.
CO5	Understand the working of phased array radars and navigational aids.

Detailed Syllabus:

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

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

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

Detection: Introduction, Matched Filter, Detection Criteria, Detector characteristics.

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

Textbooks:

1. M.I. Skolnik, Introduction Radar Systems, Second Edition, Mc Graw Hill Book Co., 2002, 3e.
2. F.E. Terman, Radio Engineering, Mc Graw Hill Book Co, 1955, Fourth Edition.

EC3331	Computational Electromagnetics	DEC	3–0–0	3 Credits

Pre-requisites: Engineering Electromagnetics

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

CO 1	Learn the fundamentals of different numerical methods, electromagnetic theorems, integral equations versus differential equations, radiation and edge conditions, and modal representation of fields in bounded and unbounded media.
CO 2	Understand finite difference schemes, finite differencing of parabolic PDE, hyperbolic PDE, elliptic PDE, accuracy and stability of FD solutions and practical applications in guided structure.
CO 3	Analyze finite differences, finite difference representation of Maxwell's equations and wave equation, numerical dispersion, Yee's finite difference algorithm, stability conditions, programming aspects, absorbing boundary conditions.
CO 4	Apply typical finite elements, Solution of two-dimensional Laplace and Poisson's equations, solution of scalar Helmholtz equation.

Detailed Syllabus:

Review of EM theory: Review of EM Theory, Classification of EM Problems, boundary condition, Applications of electromagnetics in research and industry, Historical development of Computational Methods.

Integral equation methods: introduction to integral equations, surface integral equations: mathematical derivation of Huygen's principle, introduction to Green's functions: 1D example of string, 2D and 3D wave equation.

Finite difference method: Finite difference scheme, differencing of parabolic, hyperbolic and elliptic PDEs, application to practical boundary value problems.

Variational and Moments method: Elements of calculus of variation, construction of functionals from PDEs, Reyleigh methods, weighted residual methods, Galerkin method, and practical application. Elements of Integral equation, Green's function, application to quasi-static problems, scattering problems, radiation problems.

Finite Element methods: Solution of Laplace's equation, Poisson equation & wave equation, mesh generation in 2D & 3D, FEM for exterior problems, FDTD analysis in one and two dimensions, the FDTD grid and the Yee algorithm, numerical stability, absorbing boundary conditions and perfectly matched layers.

Applications of computational electromagnetics: Inverse problems; Hertz dipole & antenna; radiation pattern; Pocklington's integral equation; source & circuit modelling of antenna; mutual coupling in antenna; hybrid methods.

Text Books:

1. A. F. Peterson, S. L. Ray, and R. Mittra, Computational Methods for Electromagnetics. New York, NY, USA: IEEE Press, 1998.
2. C. A. Balanis, Advanced Engineering Electromagnetics, 3rd ed. Hoboken, NJ, USA: Wiley, 2024.

3. W. C. Chew, Waves and Fields in Inhomogeneous Media. New York, NY, USA: IEEE Press, 1995.
4. L. Volakis, A. Chatterjee, and L. C. Kempel, Finite Element Method for Electromagnetics: Antennas, Microwave Circuits, and Scattering Applications. New York, NY, USA: Wiley-IEEE Press, 1998.

Learning Resources

1. **https://archive.nptel.ac.in/courses/108/106/108106152/**
2. **https://archive.nptel.ac.in/courses/108/101/108101090/**

EC3341	Array Signal Processing	DEC	3–0–0	3 Credits

Pre-requisites: Digital signal processing

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

CO 1	Obtain basic understanding of spatial signals and its analysis
CO 2	Synthesis and Design of Linear & Planar Arrays. Analyze the statistical behavior of signals in array processing applications.
CO 3	Develop Eigenspace, Beam space, and Broadband Beamformers for various communication and radar applications.
CO 4	Optimize adaptive array configurations for improving signal reception and interference suppression.

Detailed Syllabus:

Arrays and Spatial Filters: Review of Antenna and its parameters. Uniform Linear Array, Array Steering, Array Performance, Linear Aperture, Rectangular Arrays, Circular Arrays, Circular Apertures, Non-planar Arrays

Synthesis of Linear Arrays, Planar Arrays and Apertures: Spectral Weighting, Array Polynomials, Minimum Beamwidth, Null Steering, Spatially Non-uniform Linear Arrays, Snapshot Models, Space-time Random Process, Broadband Arrays, Beamforming for wideband signals, Array design for non-sinusoidal (wideband and UWB) signals

Adaptive Beamformers: Optimum Beamformers, Minimum Variance Distortionless Response (MVDR) and the Linear Constraint Minimum Variance (LCMV) Beamformers, Eigenspace Beamformer, Beam space Beamformer, Broadband Beamformer, Parametric Estimation, Recursive Least Squares (RLS), Least Mean Squares (LMS), Gradient Algorithms

Parameter Estimation and Direction of Arrival Estimation: Cramer-Rao Bounds, Maximum

Likelihood Estimation, Capon methods, Subspace methods - MUSIC, Minimum-Norm and ESPRIT techniques.

Textbooks:

1. Harry L. Van Trees, Optimum Array Processing: Part IV of Detection, Estimation, and Modulation Theory, Wiley, 2002.
2. Don H. Johnson and Dan E. Dudgeon, Array Signal Processing: Concepts and Techniques, Prentice-Hall, 1993.
3. Wideband Beamforming: Concepts and Techniques – Wei Liu and Stephan Weiss, Wiley, 2010.
4. P. Stoica and R. L. Moses, Spectral Analysis of Signals, Prentice Hall, 2005.
5. D. G. Manolakis, V. K. Ingle and S. M. Kogon, Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing, McGraw-Hill, New York, 2000.

EC 3351	**Modern Antenna Design**	**DEC**	**3-0-0**	**3 Credits**

Pre-Requisites: **Transmission lines and Antennas**

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

CO-1	To Familiarize with modern antennas.
CO-2	To study about various requirements from antennas for the 5G communication system.
CO-3	Understanding the concept of MIMO antenna design.
CO-4	Understanding the concept of antenna arrays for beam scanning.
CO-5	To study the effect of fabrication and measurement challenges.

Syllabus:

Modern Antennas: Revision of antenna parameters, Compare performance of different wire antennas and aperture antennas, contemporary antenna designs such as microstrip patches, PIFAs, and fractal antenna design, reconfigurable, metamaterial, and wearable antennas.

5G Communication System: Introduction to 5G Communication Systems, 5G frequency spectrum, 5G network architecture, 5G Antenna Design Fundamentals, Key antenna requirements for 5G, Antenna types for 5G. Advanced 5G Antenna Technologies, Challenges & Future Trends in 5G Antennas.

MIMO Antennas: Fundamentals of MIMO Systems, MIMO Antenna Design, Key parameters for antenna design in MIMO systems, Effect of mutual coupling on antenna performance, Introduction to MIMO beamforming techniques, Direction of Arrival (DOA) estimation and beamforming algorithm, Case studies: MIMO in LTE, 5G, Wi-Fi, and other wireless networks.

Beam Scanning: Fundamentals of Beamforming and Beam Steering, Phased Array Antennas, Beam Scanning mechanism: mechanical beam steering, electronic beam steering, Hybrid beam steering, Beam Scanning and Its Impact on Radiation Patterns, Adaptive Beamforming and Scanning, Beamforming in 5G.

Fabrication and Measurement Challenges: Materials and Substrates for Modern Antennas, Fabrication Techniques for Modern Antennas, Measurement Challenges in Modern Antennas, Antenna Testing in Complex Environments, Fabrication and Measurement of microstrip patch Antenna.

Text Books:

1. Koul, S.K., & Karthikeya, G.S. (2020). Millimeter Wave Antennas for 5G Mobile Terminals and Base Stations (1st ed.). CRC Press.
2. S. Ahmadi, 5G Mobile Networks: A Systems Approach. Cham, Switzerland: Springer, 2019.
3. J. R. O. D. T. W. F. S. Lee, MIMO Antenna Systems for 4G Mobile Terminals. Wiley, 2009.
4. H. W. Kogelnik and H. A. Haus, Beam Scanning Antennas: Principles and Design. Wiley, 1992.
5. E. Dahlman, S. Parkvall, and J. Skold, *5G NR:* The Next Generation Wireless Access Technology. 2nd ed. Amsterdam, Netherlands: Academic Press, 2020.
6. R. C. Hansen, Phased Array Antennas. 2nd ed. Wiley-IEEE Press, 2009.

Learning Resources:

1. **https://archive.nptel.ac.in/courses/108/101/108101092/**

EC 4311	**Microwave Integrated Circuits**	**DEC**	**3-0-0**	**3 Credits**

Pre-Requisites: EC2041 Transmission Lines and Antennas

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

CO-1	Understand the basics of Scattering matrix and two port characterization and signal flow graphs.
CO-2	Analyze the working principles and design of couplers and power dividers.
CO-3	Design the different types of microwave filters and their implementation
CO-4	Understand the design complexities of microwave amplifier and its stability features.
CO-5	Understand the design complexities of oscillators and mixers.

Syllabus:

Microwave Network Analysis: S-parameters and ABCD parameters, Signal Flow Graphs and Vector Network Analyzer (VNA).

Power Dividers and Couplers: Basic Properties of Dividers and Couplers, Scattering matrix of 3- and 4-port junctions; Design of T-junction and Wilkinson power dividers; Design of Coupled Line Coupler, Design of hybrids 90˚ and 180˚.

Microwave Planar Filters: Periodic structures, Filter design by the Image Parameter method, Filter design by the Insertion Loss method, Filter transformations, Filter implementation, Stepped-Impedance Low-Pass filters, coupled line filters, Filters using coupled resonators.

Microwave Amplifier Design: Two-Port Power Gains, Stability of an Amplifier, Stability Circle, Design for Maximum Gain (Conjugate Matching), Constant Gain Circles and Design for Specified Gain, Noise, Noise figure circles, Design of Low-Noise Amplifier. Classification of Power Amplifier.

Oscillators and Mixers: One-port oscillator, Load matching circuit for the one-port oscillator, Two-port oscillator, Design of two-port transistor oscillator. Single Ended Mixers, Single Balanced Mixers, Double Balanced Mixers, Image Reject Mixers.

Text Books:

1. Pozar, D.M., Microwave Engineering, 4th Ed., John Wiley & Sons, 2012.
2. Liao, S.Y., Microwave Devices and Circuits, 3rd Ed PEARSON INDIA. 2000.
3. K. C. Gupta, et al., Computer-Aided Design of Microwave Circuits, Artech House, Dedham, 1981, pp. 131-134.
4. Collin, R.E., Foundations for Microwave Engineering, 2nd Ed., John Wiley & Sons.2001.

Learning Resources:

1. **https://archive.nptel.ac.in/courses/117/101/117101119/**

EC4321	**Microwave and Millimeter-Wave Imaging**	**DE C**	**3–0–0**	**3 Credits**

Pre-requisites: Electromagnetics, Signal Processing, Antenna Theory

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

CO 1	To introduce the principles and applications of microwave and millimeter-wave imaging.
CO	To explore various imaging techniques, including near-field, far-field, UWB radar, and

2	millimeter-wave imaging.
CO 3	To develop an optimized imaging system using beamforming and array processing techniques.

Detailed Syllabus:

Introduction to Microwave and Millimeter-Wave Imaging: Overview of microwave and millimeter-wave imaging systems, Comparison with other imaging modalities (X-ray, ultrasound, infrared, etc.), Electromagnetic wave interaction with different materials.

Electromagnetic Wave Propagation and Scattering: Maxwell's equations and wave propagation principles**,** Reflection, refraction, diffraction, and scattering of microwaves and millimeter waves**,** Radar cross-section (RCS) and object detection**.**

Microwave and Millimeter-Wave Imaging Techniques: Near-field vs. far-field imaging**,** Tomographic microwave imaging**,** Synthetic Aperture Radar (SAR) and Ground Penetrating Radar (GPR)**.**

Ultra-Wideband (UWB) Radar Imaging: Introduction to UWB radar and its advantages in imaging, UWB pulse generation and signal processing, Time-domain and frequency-domain approaches for UWB imaging, Applications of UWB radar in biomedical, security, and industrial monitoring.

Millimeter-Wave Imaging: Fundamentals of millimeter-wave (MMW) imaging**,** Atmospheric absorption and propagation at millimeter-wave frequencies**,** Passive vs. active millimeter-wave imaging techniques**,** Security screening and automotive radar applications**.**

Image Reconstruction and Array Processing for Imaging: Inverse scattering problems and image reconstruction, Back projection and Fourier-based methods, Iterative reconstruction techniques (Born approximation, Distorted Born Iteration Method), Beamforming and array processing for imaging.

Textbooks:

1. M. Pastorino, Microwave Imaging. Hoboken, NJ, USA: Wiley, 2010.
2. K.-S. Chen, Principles of Synthetic Aperture Radar Imaging: A System Simulation Approach, 1st ed. Boca Raton, FL, USA: CRC Press, 2015.
3. J. D. Taylor, Ed., Ultra-Wideband Radar Technology. Boca Raton, FL, USA: CRC Press, 2001.
4. Mark E. Davis, Millimeter-Wave Radar Imaging.
5. R. Fazel-Rezai, Ed., Biomedical Engineering – From Theory to Applications. Rijeka, Croatia: InTech, 2011.
6. O. Scherzer, Inverse Problems in Imaging, in Handbook of Mathematical Methods in Imaging, O. Scherzer, Ed. New York, NY, USA: Springer, 2011, pp. 85–182.

Open Electives

EC3911	Introduction to Communication Technologies	OEC	3-0-0	3 Credits

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

CO1	Explain the basic components and working principles of analog and digital communication systems.
CO2	Compare wired and wireless communication media (e.g., optical fiber, radio waves) and their practical applications
CO3	Interpret key terminologies (e.g., SNR, multiplexing, bandwidth) about communication systems.
CO4	Understand and explain the modern communication technologies (e.g., cellular networks, Wi-Fi, Satellite Communication)

Detailed Syllabus:

Introduction to Communication Systems: Definition, need, and evolution of communication systems. Block diagram of a communication system: Transmitter, Channel, Receiver. Types of communication: Analog vs. Digital, Wired vs. Wireless. Key performance metrics: Bandwidth, SNR, Data Rate. Examples of Communication systems: Telephone, Radio etc.

Basic Concepts: Analog and Digital Signals: time-domain and frequency-domain representation; Noise in Communication: Types, effects; Transmission Media: Guided (Twisted Pair, Coaxial, Optical Fiber), Unguided (Radio Waves, Microwaves);

Digital Communication: Sampling and Quantization, Pulse Modulation Techniques: PCM, PAM, PWM, PPM (basic concepts); Digital Modulation Techniques: ASK, FSK, PSK (basic concepts); Multiplexing: TDM, FDM. Error Correction and Detection: Parity, CRC; Multicarrier and Spread Spectrum modulation (basic concepts).

Modern Communication Technologies: Wireless Communication: Wireless channel, Cellular Communication, Evolution of Cellular Networks (1G to 5G), Wi-Fi, Bluetooth; Optical Communication: Basics of Fiber Optics, Optical transmitter/receiver basics; Satellite Communication: Basic characteristics of Satellites, System Elements, Frequency spectrum Allocation, Satellite Orbit Configurations (GEO, LEO, MEO); Practical Applications & Case Studies of modern communication technologies.

Textbooks:

1. Proakis, J. G. and Salehi, M. 2001. Communication Systems Engineering, 2nd Edition, Upper Saddle River, NJ, USA: Prentice-Hall.
2. Haykin, S. and Moher, M. Introduction to analog and digital communications, 2nd edition. Wiley.
3. William C. Y. Lee, Wireless and Cellular Communications, 3rd Edition, The McGraw-Hill Companies, Inc.

4. Gordon Golboch, Wireless Networking: Introduction to Bluetooth and WiFi, Amazon Digital Services (2017).
5. Stuart Secgin, Evolution of Wireless Communication Ecosystem, IEEE Press (2023).
6. John M Senior, Optical Fiber Communication: Principles and Practice, 3rd Edition, Pearson (2009).
7. Bruce R. Elbert, Introduction to Satellite Communication, 3rd Edition, Artech House (2008).

EC3921	Elements of Statistical Learning	OEC	3-0-0	3 Credits

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

CO1	Understand key concepts like supervised vs. unsupervised learning, bias-variance trade-off, and model interpretability.
CO2	Implement linear regression, logistic regression, and regularization methods in solving practical problems.
CO3	Implement unsupervised learning techniques including clustering and dimensionality reduction.
CO4	Assess and compare models' performance using confusion matrix, ROC curves and other metrics.

Detailed Syllabus:

Mathematical Foundation: Linear Algebra: System of Linear equations, Vector Spaces, Eigen decomposition and diagonalization, Singular Value decomposition; Basic Probability and Statistics: Bayes' Rule, Random Variables, Probability distributions (Gaussian, Binomial, Poisson), Expectation, Variance and Covariance, Hypothesis testing and confidence intervals. Vector Calculus: Differentiation, Partial differentiation and Gradients of vector valued functions.

Supervised learning: Linear methods for regression, Overfitting, underfitting, and Model Complexity: Bias-Variance Trade off, Cross Validation; Regularization Techniques: Ridge regression, Lasso regression; Bayesian learning, Linear methods for classification: Linear discriminant analysis, Logistic Regression, Probabilistic generative and discriminative models; Bayesian Logistic Regression, Model assessment and selection, Model evaluation metrics.

Kernel Methods: Kernel smoothing: 1-dimensional kernel smoothers, Local regression; Kernel density estimation and classification, Radial basis function networks, Support Vector Machines (SCM), Multiclass SVMs, Gaussian mixture models for density estimation and classification

Unsupervised learning: Introduction, Clustering Methods: K-means clustering, Hierarchical clustering, Density based clustering, Principal component analysis (PCA): Probabilistic PCA, Kernel PCA.

Textbooks:

1. Hastie, T., Tibshirani, R., & Friedman, J. The Elements of Statistical Learning: Data Mining, Inference, and Prediction (2nd ed.). New York: Springer (2009).
2. Deisenroth, M. P., Faisal, A. A., & Ong, C. S. Mathematics for Machine Learning. Cambridge: Cambridge University Press (2020).
3. G. James, D. Witten, T. Hastie, R. Tibshirani, and J. Taylor, An Introduction to Statistical Learning with Applications in Python, Springer, Cham, (2023).
4. Bishop, C. M. Pattern Recognition and Machine Learning, 1st edition, Springer (2009).
5. Aurelien Geron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow O'Reilly Media (2019).

EC3931	**Introduction to Embedded Systems**	**OEC**	**3–0–0**	**3 Credits**

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

CO1	Identify the key applications, design considerations, and challenges involved in embedded systems.
CO2	Understand the architecture and components of microcontrollers and differentiate them from microprocessors.
CO3	Explain the roles of key hardware components in embedded system design.
CO4	Develop embedded software using compilers, IDEs, and debugging tools.
CO5	Understand RTOS concepts and inter-process communication.

Detailed Syllabus:

Introduction to Embedded Systems: Introduction to Embedded Systems and their significance in daily life, Comparison with general-purpose computing systems, History, classification, and major application areas, Embedded product development life cycle, Purpose, characteristics, and key design challenges of embedded systems, Common performance metrics.

Embedded System Hardware Fundamentals: Difference between microcontroller and microprocessor, Overview of a basic microcontroller architecture (RISC, CISC)**,** Introduction to processors: General-purpose vs. application-specific**,** Understanding memory types: ROM, RAM, interface-based memory classification**,** Introduction to sensors and actuators with real-world examples**,** Support circuits: Reset, brown-out protection, oscillators, real-time clock, watchdog timer**,** Communication interfaces; Introduction to embedded system boards.

Software Development: Cross assemblers/compilers, Compiler Tool chains – GCC and ARM, Device Driver, Firmware, Middleware - Debugging tools: Emulators, Simulators, In-Circuit Debuggers, Integrated Development Environment.

Embedded Real –Time Operating Systems: Introduction to basic concepts of RTOS- Task, process & threads, Multiprocessing and Multitasking, Scheduling algorithms, Semaphores, Mutex, Inter-task communication: Message queues, signals, pipes, Priority Inversion problem.

Textbooks:

1. K.V Shibu, Introduction to Embedded Systems, Mc Graw Hill India, second edition, 2016.
2. Santanu Chattopadhyay, Embedded Systems Design, PHI, 2013.
3. Frank Vahid, Tony Givargis, Embedded System Design, John Wiley
4. Tianhong Pan and YI Zhu, Designing Enbedded System with Arduino: A Fundamental Technology for Makers, Springer, 2017.

5. Embedded/Real-Time Systems: Concepts Design and Programming, K.V.K.K. Prasad Dreamtech, 2005
6. Lyla B Das, Embedded Systems: An Integrated Approach, Pearson, 2013
7. David E. Simon, An Embedded Software Primer, CD-Rom Edition, Addison Wesley, 2000.

EC4911	**Basics of Quantum Optics and Communication**	**OEC**	**3–0–0**	**3 Credits**

Prerequisites: None

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

CO1	The basics of Quantization of EM wave and Quantum Optics
CO2	The basics of entangled particles generation.
CO3	The basics of linear optics and single photon based concepts
CO4	The basics of Quantum Interference Effects
CO5	The central ideas in Quantum Cryptography**.**
CO6	Central Ideas of Quantum Internet

Detailed Syllabus:

Quantization of the Electromagnetic field, quadrature operators for fields, vacuum fluctuations and vacuum noise, uncertainty relation, number states, quantum phase, coherent states, phase space pictures of coherent states, squeezed states, photon number distributions in different states.

Twin-photon generation with non-linear interactions, parametric generation of light, spontaneous parametric down-conversion, optical parametric amplifiers and optical parametric oscillator.

Linear Optics with Quantized Fields: Beam splitter transformations, single and two photon interference, Michelson and Mach-Zehnder interferometer, and Hong-Ou Mandel dip. Hanbury-Brown-Twiss experiment, Photon bunching and anti-bunching, Einstein-Podolsky-Rosen (EPR) Paradox, Entangled State, Bell's Inequality.

Entanglement and Bell Theorems, Bell Measurements and Tests

Theory of photodetection, direct, balanced, and homodyne detection

No cloning theorem, Quantum Key Distribution protocols, BB84, E91, BBM92, B92, COW, DPS.

Two level atom, interaction of light with matter, Jaynes-Cummings model.

Quantum Memories, Quantum repeaters, Quantum Teleportation protocol, Quantum Dense coding

Textbooks:

1. Nielsen and Chuang Cambridge, Quantum computation and quantum information, University Press, Cambridge, 2010
2. A Pathak, Elements of Quantum Computation and Quantum Communication, Boca Raton, CRC Press (2015)
3. Gisin, Nicolas, et al. Quantum cryptography, Reviews of modern physics 74.1 (2002): 145

4. Christopher Gerry and Peter Knight, Introductory Quantum Optics, Cambridge University Press, 2004

5. Mark Fox, Quantum Optics: An introduction, Oxford University Publishers, 2006

EC4921	**Thin film Deposition Techniques and Applications**	**OEC**	**3-0-0**	**3 Credits**

Prerequisites: None

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

CO1	Understand the fundamentals of thin films, including their properties, historical development, and diverse applications.
CO2	Describe and compare different Physical Vapor Deposition (PVD) techniques, including evaporation and sputtering methods.
CO3	Analyze Chemical Vapor Deposition (CVD) and Atomic Layer Deposition (ALD) techniques, their mechanisms, and applications.
CO4	Evaluate thin film properties, deposition parameters, and characterization methods for optimizing film quality and performance.

Detail Syllabus:

Module 1: Fundamentals of Thin Films

- Introduction**:** Definition, importance, and historical advancements.
- Applications**:** Use in diverse fields such as microelectronics, optics, energy devices, MEMS, and biomedical coatings.
- Essential Film Properties: Thickness control, adhesion quality, stress effects, and microstructural characteristics.

Module 2: Deposition Techniques – Physical Methods

- Overview of Physical Deposition**:** Importance of vacuum technology, pressure considerations, and molecular transport.
- Types of Physical Vapor Deposition (PVD)**:**
  - Evaporation Processes**:**
    - Thermal Evaporation: Heating mechanisms (resistive heating, boat sources) and key applications.
    - Electron Beam Evaporation: High-energy beam interaction with materials, advantages in purity and high-temperature deposition.
  - Sputtering Methods**:**
    - DC Sputtering: Plasma-based material ejection, role of target materials.
    - RF Sputtering: Advanced method for insulating material deposition.

Module 3: Deposition Techniques – Chemical Methods

- Chemical Vapor Deposition (CVD)**:**
  - Reaction Kinetics and Thermodynamics: Gas-phase and surface interactions.
  - CVD Variants**:**
    - Atmospheric Pressure CVD (APCVD) and Low-Pressure CVD (LPCVD) – process conditions and material applications.
    - Metal-Organic CVD (MOCVD)**:** Use of organometallic precursors (e.g., TMGa, TMIn) for compound semiconductor growth (GaN, III-V materials).
- Atomic Layer Deposition (ALD)**:**
  - Self-Limiting Reaction Mechanism**:** Stepwise monolayer growth.
  - Application Areas: Nanoscale coatings, high-κ dielectrics (HfO_2).

Module 4: Characterization and Practical Considerations

- Key Performance Metrics: Deposition rate, composition control, film adhesion, and surface morphology.
- Material Behavior in Thin Films: Stress evolution, grain growth, and interfacial adhesion.
- Quality and Stoichiometry Analysis: Techniques for ensuring film uniformity and reproducibility.

Module 5: Industry Applications and Future Prospects

- Role in Engineering Fields**:**
  - Microelectronics**:** Integrated circuits and semiconductor coatings.
  - Optoelectronics: Thin films in LEDs and photodetectors.
  - Mechanical Engineering**:** Hard coatings for tools, wear-resistant and corrosion-resistant coatings.
  - Biomedical Coatings**:** Anti-microbial and biocompatible thin films.

Recommended Textbooks

1. Donald L. Smith, Thin Film Deposition: Principles and Practice.

2. Krishna Seshan, Handbook of Thin Film Deposition.

3. Jong-Hee Park and T.S. Sudarshan, Chemical Vapor Deposition.

4. Milton Ohring, Materials Science of Thin Films.

Service Courses (ESC) offered by ECE to other departments

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code	Level	Offering Dept
1	EC1511	Basics of Electronics Engineering	2	0	0	2	ESC	1	Civil/Mech.
2	EC1521	Signals and Systems for Electrical Engineers	3	0	0	3	ESC	1	EEE
3	EC1531	Digital Logic Design	3	0	0	3	ESC	1	CSE
4	EC1541	Microprocessor	2	0	0	2	ESC	1	CSE
5	EC1542	Microprocessor Laboratory	0	0	3	2	ESC	1	CSE
6	EC2511	Modelling and Optimization Techniques	3	0	0	3	ESC	2	CSE

EC1511	Basics of Electronics Engineering	ESC	2 – 0 – 0	2 Credits

Course Outcomes:

CO1	To explain the role of Electronics Engineering in other branches of engineering
CO2	To understand the basic building blocks of digital and analog electronic circuits
CO3	To Understand the behavior and operation of electronic devices
CO4	Design electronic circuits using diode, transistor ideal Op-amp, design of simple combinational and sequential circuits and realize the importance of various analog and digital electronic systems

Detailed Syllabus:

Introduction to electronics systems, Diode circuit models and applications: Introduction to circuit models, Clippers and Clampers, Zener diode.

Transistors –BJT and MOSFET: - BJT construction and operation, BJT configurations, BJT current components BJT characteristics, Transistor as an amplifier and switch, MOSFET.

Integrated Circuits: Operational amplifiers Characteristics and applications, linear operations using Opamps.

Digital Circuits: Number systems and logic gates, Combinational Logic circuits, Sequential Circuits, Analog to Digital and Digital to Analog converters (ADC/DAC).

Miscellaneous Electronic Devices: - SCR, LED, Photodiode, Laser, Solar Cells, Sensors.

Laboratory measuring instruments: principles of digital multi-meters, Cathode ray oscilloscopes (CRO).

Text Books:

1. Bhargava N. N., D C Kulshreshtha and S C Gupta, Basic Electronics & Linear Circuits, 2nd Edition, Tata McGraw Hill, 2013.
2. S. Sedra and K. C. Smith, Microelectronic Circuits, Oxford University Press , 6th Edition
3. Leach , Malvino, Saha, Digital Principles and Applications, McGraw Hill Education , 8th Edition
4. Boylestad, Robert L., Louis Nashelsky, Electronic Devices and Circuits, Pearson , 11th Edition
5. Helfrick and Cooper, Modern Electronic Instrumentation and Measurement Techniques, PHI, 2011
6. Neil Storey, Electronics A Systems Approach, 4th Edition, Pearson Education Publishing Company Pvt Ltd.

EC 1521	Signals and Systems for Electrical Engineers	ESC	3–0–0	3 Credits

Prerequisites: None

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

CO1	Classify the signals as Continuous time and Discrete time
CO2	Analyze the spectral characteristics of signals using Fourier analysis
CO3	Classify systems based on their properties and determine the response of LTI system using convolution.
CO4	Identify system properties based on impulse response and Fourier analysis
CO5	Apply transform techniques to analyze continuous-time and discrete-time signals and systems
CO6	Comprehensive understanding of control systems, order of systems & stability Analysis

Detailed Syllabus:

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

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

FOURIER SERIES REPRESENTATION OF PERIODIC SIGNALS: Response of LTI systems to Complex Exponentials, Fourier series Representation of CT periodic Signals, properties of CT Fourier Series, Fourier Series representation of DT periodic Signals, properties of DFS, Fourier series and LTI Systems, Filtering, Examples of CT filters, Examples of DT filters.

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

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

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

LAPLACE TRANSFORMS: Review of Laplace transforms, Inverse Laplace transform, Concept of region of convergence (ROC) for Laplace transforms, Properties of Laplace Transforms. relation between Laplace and Fourier transforms.

Textbooks:

1. Signals and Systems, Alan V. Oppenheim, Alan S. Willsky, S. Hamid Nawab, Prentice Hall India, 2nd Edition, 2009.
2. Linear Systems and Signals, B.P Lathi, 2nd edition Oxford University, 2008.
3. Fundamentals of Signals and Systems, Micheal J Roberts, Special Indian edition, Tata Mc Graw hill, 2010.
4. Digital Signal Processing: Principles, Algorithms and Applications, Fourth Addition, J. Proakis and D. Manolakis, Pearson,2014.
5. S.Haykin and Barry Van Veen, Signals and Systems, 2nd Edition Wiley, 2007

EC1531	**Digital Logic Design**	**ESC**	**3–0–0**	**3 Credits**

Prerequisites: None

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

CO1	Design of combinational and sequential logic circuits and develop Verilog model
CO2	Understand characteristics of the TTL/CMOS logic families and realize Boolean equation using CMOS logic
CO3	Understand the concepts of Combinational and Sequential Circuits
CO4	Understand SRAM/DRAM organization and periphery circuitry, operation of SRAM cell, DRAM cell, DDR2/DDR4 and FPGA/CPLD

Syllabus:

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

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

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

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

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

Text Books:

1. Morris. M. Mano, Michael D. Ciletti, Digital Design. Fourth Edition, Prentice-Hall India. 2008.
2. William J. Dally and John W. Poulton, Digital Systems Engineering, Cambridge University Press, 2008.

3. Schilling, Herbert Taub and Donald, Digital Integrated Electronics, Tata McGraw-Hill, 2008.
4. Digital Design: With an Introduction to the Verilog HDL, VHDL, and System Verilog, 6th edition.
5. Jayaram Bhasker, Verilog Primer, Prentice-Hall India, 1998,3rd edition.

Refence Books:

1. Thomas L. Floyd, Digital Fundamentals, 11th Edition, Pearson 2015
2. Sameer Palnitkar, Verilog HDL: A guide to digital Design and Synthesis, Pearson, 2003, 2nd edition.
3. John F Wakerly, Digital Design Principles and Practices, Prentice Hall India, 2001, 3rd Edition.
4. Franklin P. Processor, David E. Winkel, The Art of Digital Design: An Introduction to Top-Down Design, PTR Prentice Hall, 1987, 2nd Edition.

EC1541	**Microprocessor**	**ESC**	**2-0-0**	**2 Credits**

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

CO1	Understand the typical 16-bit microprocessor
CO2	Develop assembly language programming basics for 8086
CO3	Understand the basic serial I/O and interrupt mechanism used in 8086
CO4	Understand the data transfer techniques using microprocessor

Detailed Syllabus:

Introduction of Microcomputer System: Architecture of 16-bit Microprocessor: Intel 8086 microprocessor, Pin description and internal architecture.

Operation and Control of Microprocessor: Timing and control unit, op-code fetch machine cycle, memory read/write machine cycles, I/O read/write machine cycles, interrupt acknowledge machine cycle, state transition diagram.

Instruction Set: Addressing modes; Data transfer, arithmetic, logical, branch, stack and machine control groups of instruction set, macro-RTL and micro-RTL flow chart of few typical instructions; Unspecified flags and instructions.

Assembly Language Programming: Assembler directives, simple examples; Subroutines, parameters Interfacing: Interfacing of memory chips, address allocation technique and decoding; Interfacing of I/O devices, LEDs and toggle-switches as examples, memory mapped and isolated I/O structure; Input/Output techniques: CPU initiated unconditional and conditional I/O transfer, device-initiated interrupt I/O transfer. Interrupts: Interrupt structure of 8086 microprocessor, processing of vectored and non-vectored interrupts, latency time and response time; Handling multiple interrupts

Programmable Peripheral Interface: 8259, Intel 8255, pin configuration, internal structure of a port bits, modes of operation, bit SET/RESET feature, programming; ADC and DAC chips and their interfacing.

Textbooks:

1. Barry B. Brey, "The Intel Microprocessors-Architecture, Programming and Interfacing", 8th Edition, Pearson Prentice Hall publishers, 2009

2. Hall D. V., "Microprocessor and Interfacing-Programming and Hardware", 2nd Ed., Tata McGraw-Hill Publishing Company Limited, 2008.

EC1542	Microprocessor Laboratory	ESC	0-0-3	2 Credits

CO1	Write assembly language and C programs for arithmetic operations using 8086
CO2	Interface LED, ADC and DAC modules with microprocessor-based system
CO3	Interface stepper motor, Keyboard and memory

Detailed Syllabus:

List of Experiments:

1. Write a program using 8086 Microprocessor for Decimal, Hexadecimal addition and subtraction of two Numbers.
2. Write a program using 8086 Microprocessor for addition and subtraction of two BCD numbers.
3. Arrange a set of given 32bit numbers in ascending or descending order.
4. To perform multiplication and division of two 16-bit numbers using 8086.
5. Modify the program to accommodate 32bit fixed point numbers.
6. Transfer a given set of data from one memory location to another memory location.
7. Extend the program to transfer data using the stack.
8. Gray – to – Binary and Binary – to – Gray conversion and BCD – to – Binary and Binary – to – BCD Conversion.
9. To interface a 7 segment LED with 8086.
10. To interface a DAC and ADC with 8086.
11. Generate a Square wave of variable duty cycle of given frequency at the designated output pin of 8255 chip.

Textbooks:

1. Barry B. Brey, The Intel Microprocessors-Architecture, Programming and Interfacing, 8th Edition, Pearson Prentice Hall publishers, 2009

2. Hall D. V., Microprocessor and Interfacing-Programming and Hardware, 2nd Ed., Tata McGraw-Hill Publishing Company Limited, 2008.

EC2511	**Modelling and Optimization Techniques**	**ESC**	**3 – 0 – 0**	**3 Credits**

Pre-requisites: None

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

CO1	Formulate and solve optimization problems using linear and quadratic programming (Apply)
CO2	Model transportation, inventory and network flow problems and compute optimal parameters (Apply)
CO3	Model Convex Optimization Objectives
CO4	Analyze the efficiency of optimization algorithms for linear, quadratic and convex optimization

Detailed syllabus:

Modelling with linear programming – The Simplex method, Sensitivity Analysis, Integer linear programming – Transportation Model, Network Model, Deterministic and non-deterministic inventory models, Statistical Models.

Introduction to Quadratic Programming, Constrained Optimization Problem Solving, Convex Optimization Methods, Convex hull, epigraph, and level sets

Duality for Convex Optimization, KKT Conditions, strong duality

Gradient Descent, Quasi Newton Methods, L-BFGS, Conjugate Gradient, Projected Gradient, Proximal Gradient, Interior Point Methods, Trust Region Methods.

Textbooks:

1. Hamdy A Taha, Operations Research-An Introduction, 9th Edition, Pearson, 2017
2. Jerry Banks, Hon S Carson, Barry L Nelson, David M Nicol, Discrete Event Simulation, 5 th Ed, Pearson, 2010
3. Stephen Boyd and Lieven Vandenberghe, Convex Optimization, 1st Edition, Cambridge University Press – 2004

Minor/Double Major programs

- ECE department offers a Minor in Microelectronics and a Double Major in Communication and Signal Processing.
- To get Minor degree in any engineering branch, a student has to earn 12 Credits (6 Core credits + 6 Elective Credits) prescribed for the programme.
- To get Double Major degree in any engineering branch, a student has to earn 24 Credits (12 Core credits + 12 Elective Credits) prescribed for the programme.
- The Minor & Double Major choices start from the beginning of 3rd Semester.
- The students of Minor & Double Major courses will sit with regular students in the class.
- There will a separate timetable slots for Minor & Double Major courses identified by each department to enable the students to register for these courses. Courses other than Minor & Double Major courses will not be offered during these slots.
- A student is permitted to do one Minor and one Double Major at max.
- Each department will choose a CGPA cut off (based on II Sem CGPA) such that the total of Minor and Double Major students in any branch do not cross maximum of 30 seats.

Minor in Microelectronics

S. No.	Course Code	Course Title	Credits	Offered Sem
1		EC1011 Electronic Devices and Circuits	03	III
2		EC1031 Digital System Design	03	IV
3		**Electives list:** 1. EC2011 Analog Electronic Circuits Design, 2. EC3231 Nanoelectronics: Devices and Emerging Technologies, 3. EC 4231 Quantum Transport in Modern Devices	03	V
4		**Electives list:** 1. EC3031 VLSI design, 2. EC3261 Semiconductor Device Modelling	03	VI
		TOTAL (6 Core credits + 6 Elective Credits)	**12**	

Double Major program in Communications and Signal Processing

S. No.	Course Code	Course Title	Credits	Offered Sem
1		EC1051 Probability Theory and Random Processes, EC3051 Digital Communication	06	III
2		EC1021 Signals and Systems, EC4051 Wireless Communication	06	IV
3		Electives list: **1.** EC3131 Information Theory and Coding, **2.** EC3111 Optimization techniques,	06	V

		3. EC3151 Optical communications, **4.** EC4151 Neural networks for communications and signal Processing, **5.** EC4161 Satellite Communication		
4		Electives list: **1.** EC2021 Digital Signal Processing, **2.** EC3171 Pattern recognition, **3.** EC3121 Data Networks, **4.** EC4111 Digital Image Processing, **5.** EC4121 Speech Signal Processing	06	VI
		TOTAL (12 Core credits + 12 Elective Credits)	**24**	