Revised

Ph.D. (ECE) Course Work Syllabus

(As per NEP-2020 and Curriculum and Credit Framework-2022)

[to be effective from 2023]

Electronics and Communication Engineering

School of Technology

North-Eastern Hill University

Shillong - 793 022, Meghalaya

Table of Contents

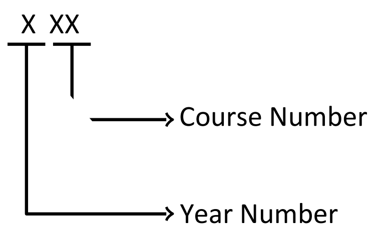
1. Syllabus Scheme

1.1 Coding Used in the Syllabus

ST - School of Technology
EC - Electronics and Communication Engineering

1.1.1 Course Coding:

Three Digit Numeric Numbers used for courses



1.2 Course Work

Branch: *Electronics and Communication Engineering* **Year:** I **Semester:** I

Sl. No.	Course Code	Course Name	Periods (Contact Hours)			Evaluation Scheme (Distribution of Marks)					Credits
Theory			**L**	**T**	**P**	**TA**	**CT**	**ST**	**ESE**	**TOT**	
1	ST -700	Research Methodology	4	0	0	10	15	25	75	100	4
2	ST - 701	Research and Publication Ethics	2	0	0	5	7	12	38	50	2
3	EC - 7XX	Elective - I	4	0	0	10	15	25	75	100	4
4	EC - 7XX	Elective - II	4	0	0	10	15	25	75	100	4
		Total	**14**	**0**	**0**	35	55	**90**	**260**	**350**	14

L - Lecture **T -** Theory **P -** Practical **TA -** Assessment by Teacher
CT - Class Test **ST -** Sub-Total **ESE -** End Semester Evaluation **TOT -** Total

Contact Hours: *14* **Total Marks:** *350* **Total Credits:** *14*

EC - 7xx *Electives*:

1. EC - 702 Mathematical Methods
2. EC - 703 Speech Processing
3. EC - 704 Advanced Wireless Communication
4. EC - 705 Microwave Theory and Techniques
5. EC - 706 VLSI Devices and Modelling
6. EC - 707 Lightwave Communication System
7. EC - 708 Spoken Language Identification Techniques
8. EC - 709 Speaker Recognition
9. EC - 710 Machine Learning
10. EC - 711 Advanced Fiber Optic Communication
11. EC - 712 Mobile Communication
12. EC - 713 Analog IC Design
13. EC - 714 Advanced Embedded Systems
14. EC - 715 High-Speed Digital Design
15. EC - 716 Advanced Control Engineering
16. EC - 717 Antenna Theory and Design
17. EC - 718 Advanced Image Processing
18. EC - 719 Computational Electromagnetics
19. EC - 720 Optical Communication Networks
20. EC - 721 Processor Architectures for VLSI
21. EC - 722 Digital IC Design
22. EC- 723 Silicon Photonics
23. EC- 724 PIC Design

L - T - P
4 - 0 - 0 = 4

2. Ph.D. Syllabus

2.1 Course Work

2.1.1 ST - 700 Research Methodology

Course Code	:	ST – 700
Course Name	:	*Research Methodology.*
Contact Hours per Week	:	*4(Four) Hours.*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Learning Outcomes:

After completing the Research Methodology course, students will learn the different aspects of research methodology, like scientific measurement techniques, sponsored research, etc.

Basic Concepts in the Philosophy of Science: What is science? The nature of truth, Subjective thinking, Objective thinking, Materialism and idealism, Logical reasoning: Inductive logic, Deductive logic, Falsifiability, Reproducibility, Causality. Proposing and testing hypotheses, Proposing postulates, Measuring the value of a parameter or a constant, Establishing a functional relationship, Developing a mathematical model, Forming a Hypothesis, the requirements for a hypothesis to be scientific, Null and alternative hypothesis, Testing of hypothesis.

Statistical Data Analysis: Sampling, Analysis of the sampled data, Distribution of the data, Measurement, and Confidence Intervals, Measurement of a value, Experimental error analysis, the Central Limit Theorem, Estimating with confidence, Measurement of a proportion, and Propagation of errors. Hypothesis Testing: Planning experiments for hypothesis testing, Null and alternative hypothesis, Experimental group and control group, Eliminating experimenter bias, Eliminating experimental subject bias, and the statistical test.

Mathematical Modeling of Physical Systems: Models built from first principles, Dimensional consistency, Modeling using dimensional analysis, Phenomenological models, and Examples. Ethical Conduct in Science: Citation, and impact of a paper, Environmental safety and experiments with living organisms, Cases of scientific misconduct.

The Art of Scientific Communication: Before you start writing, Title, Abstract, The body of the paper, Figures, Citing references, Conclusion, Acknowledgement, References, Revising the manuscript, Writing a thesis, and Text stylistics. Presentation in Seminars and Conferences: The art of preparing visual presentation material, The art of delivering a talk at a conference, Poster presentation, Preparing the poster, and Presenting a poster.

Text Books:

1. Soumitro Banerjee, ***Research Methodology for Natural Sciences***, IISc Press, 2022.
2. C. R. Kothari, Research Methodology, 2/e, New Age International Publisher, 2002.
3. S. R. Bajpai, Research Methodology, S. Chand and Sons, 2001.

2.1.2 ST - 701 Research and Publication Ethics

L-T-P
2-0-0=2

Course Code	:	$ST - 701$
Course Name	:	*Research and Publication Ethics.*
Contact Hours per Week	:	*2(Four) Hours.*
Marks Distribution	:	*Sessional Works = 12, End Semester Examination = 38.*
Questions to be Set	:	*Six.*
Questions to be Answered	:	Q1 is compulsory and has 8 marks comprising contents from all the 2 units. From Q 2- Q 6, 3 need to be answered out of 5 and having each 10 marks comprising of 2 questions from unit I and 3 questions from unit II
Duration of End Semester Examination	:	One and Half Hours

Aim: To acquaint the research scholar with research and publication ethics

Objectives: After going through this subject, students should be able to understand

- The research and publication Ethics,
- Ethics related to the use of data
- Ethics of Research and Plagiarism,

UNIT 1:

1. PHILOSOPHY AND ETHICS
a. Introduction to philosophy: definition, nature and scope, concept, branches
b. Ethics: definition, moral philosophy, nature of moral judgements and reactions

2. SCIENTIFIC CONDUCT
a. Ethics with respect to science and research
b. Intellectual honesty and research integrity
c. Scientific misconduct: Falsification, Fabrication, and Plagiarism (FFP)
d. Redundant publications: duplicate and overlapping publications, salami slicing
e. Selective reporting and misrepresentation of data

3. PUBLICATION ETHICS
a. Publication ethics: definition, introduction and importance
b. Best practices / standards setting initiatives and guidelines: COPE, WAME, etc.
c. Conflicts of interest
d. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types
e. Violation of publication ethics, authorship and contributor ship 6. Identification of publication misconduct, complaints and appeals 7. Predatory publishers and journals

UNIT II:

1. OPEN ACCESS PUBLISHING
a. Open access publications and initiatives
b. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies
c. Software tool to identify predatory publications developed by SPPU
d. Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggested, etc.

2. PUBLICATION MISCONDUCT
a. Group Discussions
i. Subject specific ethical issues, FFP, authorship
ii. Conflicts of interest

iii. Complaints and appeals: examples and fraud from India and abroad
b. Software tools
i. Use of plagiarism software like Turnitin, Urkund and other open-source software tools

3. DATABASES AND RESEARCH METRICS
a. Databases
i. Indexing databases
ii. Citation databases: Web of Science, Scopus, etc.
b. Research Metrics
i. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, CiteScore
ii. Metrics: h-index, g index, i10 index, altmetrics

Text Books:

1. Bird, A. (2006). Philosophy of Science. Routledge.
2. MacIntyre, Alasdair (1967) A Short History of Ethics. London.

Reference:

1. P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized, ISBN:978_9387480865
2. National Academy of Sciences, National Academy of Engineering and Institute of Medicine.(2009). On Being a Scientist: A Guide to Responsible Conduct in Research: Third Edition. National Academies Press.
3. Resnik, D.B. (2011). What is ethics in research & why is it important. National Institute of Environmental Health Sciences, 1-10. Retrieved from https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm
4. Beall, J. (2012). Predatory publishers are corrupting open access. Nature, 489(7415), 179- 179. https://doi.org/10.1038/489179a
5. Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance (2019), ISBN:978-81-939482-1-7. http://www.insaindia.res.in/pdf/Ethics_Book.pdf

2.1.3 EC - 7XX Elective - I & II

L	-	T	-	P		
4	-	0	-	0	=	4

2.1.3.1 EC - 702 Mathematical Methods

Course Code	: $EC-702$
Course Name	: *Mathematical Methods.*
Contact Hours per Week	: *4(Four) Hours.*
Marks Distribution	: *Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: *3(Three) Hours.*

Aim: To give an understanding of mathematical tools used in communication engineering. After this course, students should be able to use these tools in communication, signal processing, speech processing, electronics device modeling and so forth.

Objective: To introduce the concept of linear algebra, linear programming, Numerical methods and probability theory.
Linear Algebra: Vector spaces - norms - Inner Products - Eigenvalues using QR transformations - QR factorization - generalized eigenvectors - Canonical forms - singular value decomposition and applications - pseudo inverse - least square approximations –Toeplitz matrices and some applications.

Linear Programming: The simplex method- graphical concepts, the graphical solution technique, four special cases, algebraic concepts, the algebraic solution technique, four special cases revisited.Duality-the fundamental theory of duality, primal-dual relations, interpretations of the dual problem.

Numerical Methods: Introduction to Numerical Computing, Solutions of equations in one variable, Polyno mial equations and Transcendental equations, Bisection Methods, False Position method, Newton-Raphson Method, Secant Method etc. Numerical differentiation and integration: Differentiation, forward and central difference quotient, Trapezoidal Rule of numerical integration, Numerical Solutions of Ordinary Differential Equations.

Probability and Random Process: Axiomatic definitions of probability; conditional probability, independence, and Bayes theorem, continuity property of probabilities, Borel-Cantelli Lemma; random variable: probability distribution, density and mass functions, functions of a random variable; expectation, characteristic and moment-generating functions; Chebyshev, Markov, and Chernoff bounds; jointly distributed random variables: joint distribution and density functions, joint moments, conditional distributions and expectations, functions of random variables.

Text Books:

1. Saul I. Gass, Linear Programming: Methods and Applications, 5/e, Dover Publications, 2010.
2. Gilat and Subramaniam, Numerical Methods for Engineers and Scientists: An Introduction with Applications Using MATLAB, Wiley 2007.
3. H. A. Eiselt andC.L. Sandblom, Linear Programming and its Applications, Springer, 2007.
4. Richard Bronson, Gabriel B.Costa, ”Linear Algebra”, Academic Press, Second Edition, 2007.

Reference Books:

1. H. Stark and J. W. Woods, Probability and Random Processes with Applications to Signal Processing, Prentice Hall, 2002.
2. A. Papoulis and S. U. Pillai, Probability, Random Variables and Stochastic Processes, 4th Edn., McGraw-Hill, 2002.
3. Moon, T.K., Sterling, W.C., Mathematical methods and algorithms for signal processing, Pearson Education, 2000.
4. E Balagurusamy, Numerical Methods, TMH Publishing Ltd, New Delhi, 2000.

2.1.3.2 EC - 703 Speech Processing

L	-	T	-	P		
4	-	0	-	0	=	4

Course Code	: $EC - 703$
Course Name	: *Speech Processing.*
Contact Hours per Week	: *4(Four) Hours.*
Marks Distribution	: *Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: *3(Three) Hours.*

Aim: To get the overview of speech processing- fundamentals and Analysis.

Objectives: On completion of the paper, students shall be able to

- Assess the fundamentals of the speech production system
- Elaborate speech analysis

Review of Signal Processing: Review of Digital Signal Processing concepts; Short-Time Fourier Transform, and Filter-Banks.

Speech Fundamentals: Articulatory Phonetics – Production and Classification of Speech Sounds; Acoustic Phonetics, Acoustics of Speech Production.

Speech Analysis - I: Features, Feature Extraction and Pattern Comparison Techniques: Speech distortion measures, Log Spectral Distance, Cepstral Distances, Weighted Cepstral Distances and Filtering, Likelihood Distortions.

Speech Analysis - II: Spectral Distortion using a Warped Frequency Scale, LPC, PLP and MFCC Coeffi- cients, Time Alignment and Normalization: Dynamic Time Warping, Multiple Time: Alignment Paths.

Text Books:

1. Daniel Jurafsky and James H Martin, *Speech and Language Processing – An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition*, Pearson Education.
2. Lawrence Rabiner and Biing-Hwang Juang, *Fundamentals of Speech Recognition*, Pearson Education, 2003.
3. Ben Gold and Nelson Morgan, *Speech and Audio Signal Processing - Processing and Perception of Speech and Music*, Wiley- India Edition, 2006.
4. Thomas F. Quatieri, *Discrete-Time Speech Signal Processing: Principles and Practice*, Prentice Hall Inc., 2001.

Reference Books:

1. J. R. Deller, J. G. Proakis and J. H. Hansen, *Discrete Time Processing of Speech Signals*, 1993.
2. L. R. Rabiner and R. W. Schaffer, *Digital Processing of Speech Signals*, Prentice Hall, 1978.

	L - T - P
2.1.3.3 EC-704 Advanced Wireless Communication	4 - 0 - 0 = 4

Course Code	: $EC-704$
Course Name	: *Advanced Wireless Communication.*
Contact Hours per Week	: *4(Four) Hours.*
Marks Distribution	: *Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: *3(Three) Hours.*

Aim: To get a well-defined apprehension of modern wireless communication systems, which will help the students to design and evaluate wireless systems theoretically.

Objectives:

- To introduce the concepts of wireless communication.
- To make the students know about the various propagation methods, Channel models, capacity calculations, multiple antennas, and multiple user techniques used in mobile communication.

Introduction to Cellular Communication: History of cellular communication, Frequency reuse, multiple access technologies, Channel assignment strategies, Handoff strategies, Interference and system capacity, Trunking and grade of services, Trends in cellular radio and personal communication.

Wireless Channel Model: Slow and Fast Fading Wireless Channel Modeling, Rayleigh/Ricean Fading Channels, BER Performance in Fading Channels.

Diversity techniques: Diversity techniques for Wireless Communications, Basic methods of diversity combining, BER Performance Improvement with diversity, Types of Diversity - Frequency, Time, Space.

Advanced Techniques for Digital Communication: Model of spread spectrum digital communication system, Direct sequence spread spectrum signals, Frequency Hopped spread spectrum signals, other types of spread spectrum signals, Introduction to MIMO, MIMO Channel Capacity SVD and Eigenmodes of the MIMO Channel, Introduction to OFDM, Multicarrier Modulation and Cyclic Prefix, Channel model and SNR performance, OFDM Issues - PAPR.

Text Books:

1. T. S. Rappaport, *Wireless Communication Principle, and Practice*, Prentice-Hall of India, 2007.
2. Andreas Molisch, ”Wireless Communications” Wiley IEEE Press. 2007.
3. Simon Haykin, *Communication Systems*, Wiley India, 2006.
4. Arogyaswami Paulraj, ”Introduction to Space-Time Wireless Communications”, Cambridge University Press, 2006.

Reference Books:

1. Andrea Goldsmith, *Wireless Communications*, Cambridge University Press. 2005.
2. David Tse and Pramod Viswanath, *Fundamentals of Wireless Communications*, Cambridge University Press, 2005.
3. Mischa Schwartz, ”Mobile Wireless Communications” Cambridge University Press 2005.
4. J. G. Proakis and M. Salehi, *Digital Communications*, 5/e, McGraw-Hill International Edition, 2008.

2.1.3.4 EC - 705 Microwave Theory and Techniques

L	-	T	-	P		
4	-	0	-	0	=	4

Course Code	:	$EC-705$
Course Name	:	*Microwave Theory and Techniques.*
Contact Hours per Week	:	*4(Four) Hours.*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Aim: To get an in-depth knowledge of microwave theory and to design modern microwave components.

Objectives:

- To develop the concept on microwave transmission line and networks.
- Design matching circuits and other planar microwave components.
- Design of filters for modern communication systems.

Transmission Line and Networks: Review of electromagnetic field equations, The wave equation, Solution of wave equations, Radio Frequency Transmission Line Theory, Telegrapher's Equations, , Concept of Voltage and Current Wave in a Line, Characteristics impedance and characteristics admittance, Power Flow in a Transmission Line , Terminated Lines: Short circuited line, Open Circuited Line, Matrix Representation of network: The impedance matrix, The admittance matrix, ABCD matrix, Matching of Transmission Lines: The Quarterwave Transformer matching , Stub Matching. Introduction to left-handed transmission lines.

Planar Transmission Lines: Microstrip Line: EM field distribution in a Micro-strip Line, Effective Dielectric Constant, Characteristic impedance, Coplanar waveguide, Stripline, Microwave resonators: series and parallel resonant circuits, transmission line resonator, Dielectric resonators.

Microwave Passive Components: Planar Power divider, T-junction power divider, Wilkinson power divider, Directional coupler: 90-degree Hybrid, 180-degree Hybrid coupler, Lange Coupler, Ferrimagnetic Components, Ferrite Phase Shifter, Ferrite Isolator, Ferrite Circulator.

Microwave filters: Periodic structures, Filter Design by the Insertion Loss Method, Maximally Flat and Chebyshev Filter design, stepped impedance low pass filter, Band Pass and High Pass Filters, Filter using coupled line resonators. Multiband and broad banding techniques in modern filter applications.

Text Books:

1. D. M. Pozar, *Microwave Engineering*, 2/e, John Wiley, 1998.
2. Peter A. Rizzi, *Microwave Engineering: Passive Circuits*, Prentice Hall, 1/e 1987.
3. C. Caloz, T. Itoh, *Electromagnetic Metamaterials: Transmission Line Theory and Microwave Applications*, John Wiley and Sons, 2006.
4. S. M. Liao, *Microwave Devices and Circuits*, 3/e, PHI, 1995.
5. Jia-Sheng Hong, *Microstrip Filters for RF/Microwave Applications*, John Wiley and Sons, 2/e, 2011.

Reference Books:

1. R. E. Collin, *Foundations for Microwave Engineering*, Wiley-IEEE press, 2/e 2000.
2. R. Ludwig and G. Bogdanov, *RF Circuit Design: Theory and Applications*, Prentice Hall, 2/e, 2008.

2.1.3.5 EC - 706 VLSI Devices and Modelling

L - T - P
4 - 0 - 0 = 4

Course Code	: $EC - 706$
Course Name	: *VLSI Devices and Modelling.*
Contact Hours per Week	: *4(Four) Hours.*
Marks Distribution	: *Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: *3(Three) Hours.*

Aim: To get an in-depth knowledge of modeling and simulation of VLSI devices.

Objective: To implement and study different modern VLSI Devices.

Basic Device Physics: Two terminal MOS structure: Flat-band voltage, Potential balance and charge balance, Effect of Gate - substrate voltage on surface condition, Inversion, Small signal capacitance; Three Terminal MOS Structure: Contacting the inversion layer, Body effect, Regions of inversion, Pinch - off voltage.

Four Terminal MOS Transistor: Transistor regions of operation, general charge sheet models, regions of inversion in terms of terminal voltage, strong inversion, weak inversion, moderate inversion, effective mobility, temperature effects, breakdown, p - channel MOSFET.

Small Dimension Effects: channel length modulation, barrier lowering, two-dimensional charge sharing and threshold voltage, punch-through, carrier velocity saturation, hot carrier effects, scaling, effects of surface and drain series resistance, effects due to thin oxides, and high doping. Subthreshold regions.

CMOS Device Design: Scaling, Threshold voltage, MOSFET channel length; CMOS Performance Factors: Basic CMOS circuit elements; parasitic elements; sensitivity of CMOS delay to device parameters

Text Books:

1. Yuan Taur and Tak. H. Ning, *Fundamentals of Modern VLSI Devices*, 2/e, Cambridge University Press, 2013
2. Yannis Tsividis, *Operation, and Modeling of the MOS Transistor*, 2/e, Oxford University Press, 2003.

Reference Books:

1. S. M. Sze, *Physics of Semiconductor Devices*, Wiley India Private Limited, 3/e 2008.
2. Phillip E. Allen and Douglas R. Holberg, *CMOS Analog Circuit Design*, 2/e, Oxford University Press, 2002.

2.1.3.6 EC - 707 Lightwave Communication System

L	-	T	-	P		
4	-	0	-	0	=	4

Course Code	: $EC-707$
Course Name	: *Lightwave Communication Systems.*
Contact Hours per Week	: *4(Four) Hours.*
Marks Distribution	: *Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: *3(Three) Hours.*

Aim: To get an in-depth understanding of theoretical modeling and design of the fiber optic communication system based on given specifications.

Objectives: After completion of this course, students shall be able to

- Characterize the optical fiber for communication purposes.
- Compare Optical sources and Optical Detectors, and discuss transmitter design issues.
- Estimate receiver performance in terms of SNR, and BER for given specifications.
- Estimate Budget (Power, Rise time), describe WDM Technology and non-linear effects in fiber.

Introduction: Need for Fiber-Optic Communications, Basic concepts in optical communication systems, an overview of optical transmitters and receivers. Optical Fibers: Geometrical-Optics Description, Wave Propagation, Dispersion in Single-Mode Fibers, Dispersion-Induced Limitations, Fiber Losses.

Optical Sources and Transmitters: Basic Concepts, Direct and Indirect Materials, Semiconductor Laser fundamentals, single mode semiconductor laser and laser characteristics, laser signal modulation. LED basics and its characteristics. Transmitter Design: Source fiber coupling, driver circuitry.

Optical Receivers: Basic concept-responsivity, quantum efficiency, Common photodetectors- pn, p-i-n, Avalanche, and MSM Photodetectors. Receiver Design: front end, linear channel, decision circuit, and integrated receivers. Receiver Noise, Coherent Detection, Receiver Sensitivity, Sensitivity degradation, and receiver performance.

Lightwave Communication Systems: System architecture, design guidelines: loss and dispersion limited systems, power budget, and rise time budget. WDM lightwave systems, WDM components: MUX, DeMUX, couplers, optical filters. System performance issues: cross talk, scattering and fiber nonlinear effects-SPM, XPM and FWM.

Text Books:

1. Govind P. Agrawal, *Fiber Optic Communication Systems*, 4/e, Wiley India Pvt. Ltd, New Delhi, 2010.
2. Gerd Keiser, *Optical Fiber Communication*, 4/e, TMH, 2008.
3. I. P. Kaminow, Tingye Li and A. E. Willner, *Optical Fiber Telecommunications V A (Components and Subsystems)*, 5/e, Academic Press, California, 2008.
4. J. M. Senior, *Optical Fiber Communications: Principles and Practice*, 2/e, Printed Hall India Pvt. Ltd, 2004.

Reference Books:

1. I. P. Kaminow, Tingye Li and A. E. Willner, *Optical Fiber Telecommunications V B (Systems And Networks)*, 5/e, Academic Press, California, 2008.
2. S. E. Miller and Ivan Kaminow, *Optical Fiber Telecommunications II (part 2)* , 1/e, Acedemic Press, 1988.
3. J. P. Powers, *An Introduction to Fiber Optic Systems*, 2/e, Richard D. Irvin, 1996.

2.1.3.7 EC - 708 Spoken Language Identification Techniques

L	-	T	-	P		
4	-	0	-	0	=	4

Course Code	:	$EC - 708$
Course Name	:	*Spoken Language Identification Techniques.*
Contact Hours per Week	:	*4(Four) Hours.*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Aim: To get in-depth understanding of various spoken language identification techniques.

Objective: This course is designed to give a student a thorough understanding application of signal processing and statistical methods in automatic language identification.

Spoken Language Structure: Sound production and human speech system, phonetics and phonology, syllables and words, syntax and symantics.

Review of Speech Signal Representation: Short-term Fourier transforms, acoustic model of speech production, cepstral processing, perceptually motivated representations (MFCC, PLP).

Pattern Recognition Techniques: Bayes decision theory, construction of classifiers, discriminative training, unsupervised estimation methods.

Langauge and Statistical Models: Acoustic and language models, Introduction to HMM, isolated word recognition.

Text Books:

1. Xuedong Huang, Alex Acero and Hsiao-Wuen Hon *Spoken language processing*, 2/e, Prentice-Hall, 2001.
2. Daniel Jurafsky and James Marin *Speech and Language Processing*, 2/e, Prentice-Hall, 2008.
3. Lawrence Rabinerand Biing-Hwang Juang, *Fundamentals of speech recognition*, 3/e, Prentice-Hall, 2001.

Reference Books:

1. Thomas F. Quateri, *Discrete Time Speech Signal Processing: Principles and Practice*, 1/e, Pearson Education 2001.
2. Douglas O'Shaughnessy, *Speech Communications: Human and Machine,*, 2/e, IEEE Press 1999.

2.1.3.8 EC -709 Speaker Recognition

L	-	T	-	P		
4	-	0	-	0	=	4

Course Code	: $EC-709$
Course Name	: *Speaker Recognition.*
Contact Hours per Week	: *4(Four) Hours.*
Marks Distribution	: *Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: *3(Three) Hours.*

Aim: To get an in-depth understanding of the Analysis, modeling, and recognition of speech signals.

Objective: After completing this course, students shall be able to understand various concepts and techniques used for speaker recognition.

Introduction: Speaker recognition branches, Modalities, applications, theory of speech production, Concept of speaker identification and speaker verification, Anatomy of speech, Signal representation of speech, Text-dependent, Text-independent Speaker Verification, and Identification.

Extraction of features: LPCC, PLP, MFCC, fundamental speech frequency, Statistical methods of voice analysis.

Speaker modelling: Hidden Markov models (HMMs), and Gaussian mixture models (GMMs) for speaker characterization. Pattern matching: DTW, etc.

Robustness: noise and channel conditions for automatic recognition, Effects of prosody on voice recognition, Speech enhancement approaches, Analysis of non-speech vocalization, and Software tools.

Text Books:

1. Homayoon Beigi, *Fundamentals of Speaker Recognition*, Springer, 2011.
2. J. R. Deller, J. H. L. Hansen, and J. Proakis, *Discrete-Time Processing of Speech Signals*, 2/e, IEEE Press, 2000.
3. L. R. Rabiner, R. W. Schafer, *Digital Processing of Speech Signals*, Pearson, 2013.

Reference Books:

1. Ben Gold, Nelson Morgan, *Speech and Audio Processing*, Wiley, 2014.
2. Chin-Hui Lee, Frank K. Soong, *Automatic Speech and Speaker Recognition*, Kluwer Academic Publishers, 1996.
3. Amy Neustein, Hemant A. Patil, *Forensic Speaker Recognition*, Springer, 2012.

2.1.3.9 EC-710 Machine Learning

L	-	T	-	P		
4	-	0	-	0	=	4

Course Code	: $EC-710$
Course Name	: *Machine Learning.*
Contact Hours per Week	: *4(Four) Hours.*
Marks Distribution	: *Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: *3(Three) Hours.*

Aim: To obtain a broad overview of existing machine learning methods, and to understand their motivations and main ideas from a variety of perspectives.

Objective: Students shall be able to

- Explain well pose learning problems, and experimental evaluation.
- Use different supervised/unsupervised learning techniques and methods.
- Learn different probabilistic models.

Overview of Machine Learning: Basic concepts, well-posed learning problem, the concept learning task; General-to-specific ordering of hypotheses; Version spaces; Inductive bias; Experimental Evaluation: Overfitting, Cross-Validation.

Supervised Learning: Decision Tree Learning; Instance-Based Learning; k-Nearest neighbor algorithm; Support Vector Machines; Ensemble learning: boosting, bagging; Artificial Neural Networks: Linear threshold units, Perceptron, Multilayer networks, and back-propagation; Genetic Algorithms.

Probabilistic Models: Maximum Likelihood Estimation, MAP, Bayes Classifiers; Bayes optimal classifiers; Minimum description length principle; Bayesian Networks, Inference in Bayesian Networks, Bayes Net Structure Learning.

Unsupervised Learning: K-means and Hierarchical Clustering, Gaussian Mixture Models, EM algorithm, Hidden Markov Models; Learning Theory: PAC learning; Reinforcement Learning: Q-Learning.

Text Books:

1. Alpaydin Ethem, *Introduction to Machine Learning*, 2/e, Prentice Hall of India.
2. Mitchell Tom, *Machine Learning*, 2/e, McGraw Hill.
3. Christopher M. Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006.
4. Duda R. O., Hart P.E. and Stork D.G., *Pattern Classification*, 2/e, Wiley & Sons, 2006.

Reference Books:

1. P. Flach, *Machine Learning: The Art and Science of Algorithms that Make Sense of Data*, Cambridge University Press, 2012.
2. David J. C. MacKay, *Information Theory, Inference, and Learning Algorithms* , the South Asia Edition, Foundation Books.
3. Russell S. J. and Norvig P., *Artificial Intelligence: A Modern Approach*, 3/e, Prentice Hall of India.
4. Mohri M., Rostamizadeh A. and Talwalkar A., *Foundations of Machine Learning*, the MIT Press.
5. Murphy Kavin. P., *Machine Learning: A Probabilistic Perspective*, The MIT Press.
6. Ball Rasmussen C. E. and Williams C. K. I., *Gaussian Processes for Machine Learning*, the MIT Press, 2006.

2.1.3.10 EC-711 Advanced Fiber Optic Communication

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Course Code	:	$EC-711$
Course Name	:	*Advanced Fiber Optic Communication.*
Contact Hours per Week	:	*4(Four) Hours.*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Aim: To get in-depth knowledge of theoretical models and the design of advanced fiber optic communication systems based on user's requirements.

Objectives: After completion of this course, students shall be able to

- Comparison of optical amplifiers (EDFA,ROA,SOA) for loss management.
- Designing of DCF fibers, FBG and dispersion compensation for dispersion management.
- Estimate non-linear effects in optical fiber, designing lightwave systems.
- Determining non-linear techniques and devices for different applications.

Review of Fiber Optic Communication Systems: Fiber characteristics, optical sources, and detectors. Loss Management in Optical Fiber: compensation of fiber losses, EDFA- its operating principle and characteristics, Raman Amplifiers-Gain and Bandwidth, multiple pump Raman amplification, Noise Figure of RA. Optical and electrical SNR, Receiver sensitivity, and Q factor, periodically amplified lightwave systems.

Dispersion Management: Dispersion problems and its solution. Dispersion compensating fibers: condition for dispersion compensation, dispersion map, DCF design. Fiber Bragg gratings: constant periodic grating, chirped fiber gratings, sampled gratings, Dispersion equalizing filters, channels at high bit rates, and Electronics Dispersion compensation.

Control of Non-linear Effects: Impact of fiber nonlinearity, solitons in optical fibers, dispersion managed solitons, Pseudo-linear Lightwave Systems, Control of Intrachannel Nonlinear Effects. Advanced lightwave systems: modulation formats, Demodulation schemes-Synchronous and Asynchronous heterodyne; Shot noise and BER, Sensitivity degradation mechanism, Impact of nonlinear effects- nonlinear phase noise; Recent progress in a system with DBPSK, DQPSK format. Ultimate channel capacity.

Optical Signal Processing: Non-linear techniques and devices-non-linear optical loop mirrors, parametric amplifiers, non-linear effect in SOA; All Optical Flip-Flops: semiconductor lasers and SOAs, coupled semiconductor lasers and SOAs; Wavelength converters-XPM-Based Wavelength Converters, FWM-Based Wavelength Converters, Passive Semiconductor Waveguides, SOA-Based Wavelength Converters.

Text Books:

1. Govind P. Agrawal, *Fiber Optic Communication Systems*, 4/e, Wiley India Pvt. Ltd, New Delhi, 2010.
2. Gerd Keiser, *Optical Fiber Communication*, 4/e, TMH, 2008.
3. I. P. Kaminow,Tingye Li, A. E. Willner, *Optical Fiber Telecommunications V A (Components and Subsystems)*, 5/e, Academic Press, California, 2008.
4. J. M. Senior, *Optical Fiber Communications: Principles and Practice*, 2/e, Printed Hall India Pvt. Ltd, 2004.

Reference Books:

1. I. P. Kaminow, Tingye Li, A. E. Willner, *Optical Fiber Telecommunications V B (Systems And Networks)*, 5/e, Academic Press is An Imprint of Elsevier,California, 2008.
2. S. E. Miller and Ivan Kaminow, *Optical Fiber Telecommunications II (part 2)*, 1/e, Acedemic Press, 1988.
3. J. P. Powers, *An Introduction to Fiber Optic Systems*, 2/e, Richard D. Irvin, 1996.

2.1.3.11 EC - 712 Mobile Communication

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Course Code	:	$EC-712$
Course Name	:	*Mobile Communication.*
Contact Hours per Week	:	*4(Four) Hours.*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Aim: To familiarize the students with mobile radio propagation and the phenomena that occurred during propagation. Also, to give an idea about a cellular concept and system design.

Objectives: To understand

- The basic propagation technique.
- Different parameters of wireless propagation.
- Frequency reuses concept and design techniques.
- Capacity analysis of cellular systems.

Introduction: Representation of a mobile radio signal; Propagation path loss and fading: Causes, Types of Fading and Classification of Channels. Prediction of Propagation Loss: Measurements, Prediction over Flat terrain, Point-to-Point Prediction, Microcell Prediction Model.

Calculation of Fades: Amplitude Fades, Random PM and Random FM, Selective Fading, Diversity Schemes, Combining Techniques, Bit-error-rate, and Word-error-rate. Mobile Radio Interference: Co-channel and Adjacent-channel Interference, Inter-modulation, Inter-symbol, and Simulcast Interference.

Frequency Plans: Channelized Schemes and Frequency reuse, FDM, TDM, Spread Spectrum and Frequency Hopping, Cellular concept, Spectral efficiency.

Design Parameters at Base Station: Antenna Configurations, Noise, Power, and Field Strength; Design Parameters at Mobile Unit: Microcell Systems: Conventional Cellular System, Microcell System Design, and Capacity Analysis.

Text Books:

1. W. C. Y. Lee, Mobile Communications Design Fundamentals, 2/e, Wiley, 1993.
2. T. S. Rappaport, Wireless Communications, Prentice-Hall, 1996.
3. G. H. Stuber, Principles of Mobile Communications, Kluwer, 1996.

Reference Books:

1. R. Steele and L. Manzo, Mobile Radio Communications, 2/e, John Wiley, 1999.
2. P. Wong and D. Britland, Mobile Data Communication Systems, Artech House, 1995.
3. W. C. Y. Lee, Mobile Cellular Telecommunications, 2/e, McGraw Hill, 1995.

2.1.3.12 EC - 713 Analog IC Design

L	-	T	-	P		
4	-	0	-	0	=	4

Course Code	: $EC - 713$
Course Name	: *Analog IC Design.*
Contact Hours per Week	: *4(Four) Hours.*
Marks Distribution	: *Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: *3(Three) Hours.*

Aim: To get the basic approach to Design CMOS Based Analog Building Blocks.

Objectives: Students shall be able to

- Discuss the various topologies of Analog Design blocks.
- Describe the complete Design of CMOS-based OPAMP for a desired target specification.
- Explain various approaches to design of specialized circuit architectures for High-speed and Low- power.

Introduction to MOS and Basic Building Blocks: Introduction to Analog Design, Basic MOS Device Physics, Small-Signal Model for the MOS Transistor, Analog CMOS Subcircuits : MOS Switch, MOS Diode/Active Resistor, Current Sinks and Sources, Current Mirrors,Current and Voltage References, Bandgap Reference.

CMOS Amplifier Design: CMOS Single Stage Amplifiers: Inverters, Differential Amplifiers, Cascode Amplifiers, Current Amplifiers, Output Amplifiers/Buffers, Simple Operational Amplifiers: Design of CMOS Op Amps., Compensation of Op Amp, Design of Two-Stage Op Amps, Power-Supply Rejection Ratio of Two-Stage Op Amps, Cascode Op Amps.

OPAMP and Comparator Design: Frequency Response of Amplifiers, Stability and frequency compensation, Comparators: Characterization of a Comparator, Two-Stage, Open-Loop Comparator Design, Other OpenLoop Comparators, Improving the Performance of Open-Loop Comparators, Discrete-Time Comparators, High-Speed Comparators.

Low-Power and High-Speed Circuits: Bandgap References, Introduction to Switched-Capacitor Circuits, Nonlinearity and Mismatch, Oscillators, Phase-Locked Loops.

Text Books:

1. Phillip E. Allen and Douglas R. Holberg, *CMOS Analog Circuit Design*, 3/e, Oxford University Press, 2011.
2. Randall L. Geiger, Phillip E. Allen and Noel Strader,*VLSI Design Techniques for Analog and Digital Circuits* , McGraw-Hill, 2010.
3. R. Jacob Baker, *CMOS Circuit Design, Layout, and Simulation*, 3/e, Wiley-IEEE Press, 2010.
4. B. Razavi, *Design of Analog CMOS Integrated Circuits*, McGraw-Hill, 2000.

Reference Books:

1. Yannis Tsividis and Colin McAndrew, *The MOS Transistor*, 3/e, Oxford University Press, 2013.
2. R. Jacob Baker, *CMOS Mixed-Signal Circuit Design*, 2/e, Wiley-IEEE Press, 2009.

2.1.3.13 EC - 714 Advanced Embedded Systems

L	-	T	-	P		
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Course Code	: $EC - 714$
Course Name	: *Advanced Embedded Systems.*
Contact Hours per Week	: *4(Four) Hours.*
Marks Distribution	: *Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: *3(Three) Hours.*

Aim: To improve hardware knowledge for implementing Communication Systems

Objective: Students shall be able to

- Explain the latest technology-related PIC microntroller and Interfacing.
- Describe Software Development and Tools for microcontrollers.
- Explain Embedded Systems and RTOS.

PIC Microcontroller and Interfacing: Introduction, architecture, registers, instruction sets, addressing modes, timers, Interrupts, I/o Expansion, I 2C Bus Operation ,Serial EEPROM, UART-Baud Rate- Data Handling-Initialization, Special Features - serial Programming-Parallel Slave Port.

Software Development and Tools: Simulators, debuggers, cross compilers, in-circuit emulators for the microcontrollers. Interface Issues Related to Embedded Systems: A/D, D/A converters, FPGA, ASIC, diagnostic port.

Techniques for Embedded Systems: State machine and state tables in embedded design, simulation and emulation of embedded systems. High-level language descriptions of S/W for embedded system, Java embedded system design.

Real Time Operating Systems: Event-based, process based and graph-based models, Petrinet models. Real-time languages, real-time kernel, OS tasks, task states, task scheduling, interrupt processing, clocking, communication and Synchronization. Control blocks, memory requirements and control, kernel services, and basic design using RTOS.

Text Books:

1. Mazidi M. A. and J. G. Mazidi, *The 8051 Microcontroller and Embedded Systems*, 2/e, Pearson, 2002
2. Kenneth J Ayala, *The 8051 Microcontroller Architecture Programming And Applications*, 2/e, Penram International Publishing, 1996.
3. J.B. Peatman, *Design with PIC Microcontrollers*, PHE, 1998.
4. Evesham, *Developing Real:Time Systems - A Practical Introduction*, 3/e, Galgotia Publications, New Delhi, 1996.

Reference Books:

1. Kenneth Hintz and Daniel Tabak, *Micro Controllers, Architecture, Implementation and Programming*, TMH, 2005.
2. Herma K., *Real Time Systems – Design for Distributed Embedded Applications*, Kluwer Academic, 1997.
3. Gassle J, *Art of Programming Embedded Systems*, Academic Press, 1992.
4. Gajski D.D, Vahid F, Narayan S., *Specification and Design of Embedded Systems*, Prentice Hall, 1994.
5. Ball S.R, *Embedded Microprocessor Systems - Real World Design*, Prentice Hall, 1996.

2.1.3.14 EC - 715 High-Speed Digital Design

L	-	T	-	P		
4	-	0	-	0	=	4

Course Code	:	$EC-715$
Course Name	:	*High-Speed Digital Design.*
Contact Hours per Week	:	*4(Four) Hours.*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Aim: To get an in-depth understanding of the issues relating to high-speed digital systems.

Objectives: Students shall be able to

- Explain the high-speed properties of logic gates,
- Discuss issues on terminations with high-speed data transfers,
- Describe the power systems on high-speed digital systems.

Introduction to High-Speed Digital Design: Frequency and time, time and distance, lumped versus dis- tributed systems, a note about 3dB and RMS frequencies, four kinds of reactance, ordinary capacitance, ordinary inductance, a better method for estimating decay time, mutual capacitance and mutual inductance.

High-Speed Properties of Logic Gates: Brief Introduction of Power: quiescent verses active dissipation, active power when driving a capacitive load, active power due to overlapping bias currents, input power, internal dissipation and output dissipation. Speed: Introduction, effects of sudden change in voltage, effects of sudden change in current, and the bottom line-voltage margins.

Terminations: Introduction, end terminators: rise time of an end terminator, and DC biasing of end terminator. Source terminators: Introduction, resistance value of source termination and drive required by source termination. Middle terminators. Crosstalk in terminators: introduction, crosstalk from adjacent axial resistors, crosstalk from adjacent surface-mounted resistors, and crosstalk from SIP terminating resistors.

Power Systems: Introduction: providing a stable voltage reference. Distributing uniform voltage: Introduction, the resistance of power distribution wiring, the inductance of power distribution wiring and board level filtering. Everyday distribution problems: random ECL errors in a combined TTL-ECL system, too much voltage drop in distribution wiring, power glitches when plugging in cards, and EMI radiating from the power distribution wiring.

Text Books:

1. Howard Johnson and Martin Graham, *High Speed Digital Design: A Handbook of Black Magic*, Pearson Education Inc., 2004.

2.1.3.15 EC - 716 Advanced Control Engineering

L	-	T	-	P		
4	-	0	-	0	=	4

Course Code : $EC - 716$

Course Name : *Advanced Control Engineering.*

Contact Hours per Week : *4(Four) Hours.*

Marks Distribution : *Sessional Works = 25, End Semester Examination = 75.*

Questions to be Set : *Eight.*

Questions to be Answered : *Any 5(Five).*

Duration of End Semester Examination : *3(Three) Hours.*

Aim: To design a control system with desired specification after studying fundamentals of Digital Control Theory.

Objectives: After completion of this course, the student shall be able

- To develop the knowledge of sample and hold circuits, pulse transfer function and non-linear systems.
- To design the Digital Controllers and to evaluate the stability of the system.
- To analyze the discrete control system using state space representation and LYAPUNOV's stability analysis.
- To design Observer by Pole Placement Technique.

Introduction: Basic building blocks of Discrete-time Control system, Sampling Theorem, Z transform, and Inverse Z transform for applications for solving differential equations, Mapping between the S-plane and the Z-plane, Impulse sampling and Data Hold. Zero Order Hold (ZOH) and First Order Hold (FOH). Pulse Transfer Function: The Pulse transfer function, Pulse transfer function of Open loop and Closed Loop systems and Pulse transfer function of ZOH and FOH. Non-linear control systems: behavior of non-linear dynamic systems.

Digital PID Controllers: Pulse transfer function of Digital PID controller, Velocity and Position forms of Digital PID Controller, Realization of Digital Controllers, Deadbeat response and ringing of poles. Design of Discrete Time Control System by conventional methods: Stability analysis in Z-plane, Jury stability criterion, Bilinear transformations, W plane, prewarping, Z domain compensation, W plane compensation.

State Space Analysis of Discrete Time Control System: State space representation of discrete-time systems, Solution of discrete-time state space equations, State transition matrix (STM), Computation of STM by Z transformation method , Eigen Values, Eigen Vectors and Matrix Diagonalization, Discretization of continuous time state space equations. Lyapunov's stability criterion.

Pole Placement and Observer Design: Concept of Controllability and Observability, Useful transformations in state space analysis and design, Stability improvement by state feedback, Design via pole placement, State observers. Optimal Control: Quadratic Optimal Control of linear systems with and Quadratic Performance Index, Optimal State Regulator design through the Matrix Riccati Equations, Properties and Application of Optical Regulator.

Text Books:

1. B. C. Kuo, *Digital Control System*, 2/e, Oxford University Press, 2008.
2. K. Ogata, *Discrete Time Control System*, 2/e, Pearson Education, 2007.
3. M. Gopal, *Digital Control & State Variable Methods*, 3/e, Tata McGraw Hill, 2003.
4. Gene F. Franklin, Abbas Emami-Naeini and J. David Powell, *Feedback Control of Dynamic Systems*, 5/e, Pearson Education Inc., 2008.

Reference Books:

1. M Gopal, *Control Systems*, 3/e, Tata McGraw Hill, 2008.
2. Riachrd H. Middleton and Graham C. Goodwin, *Digital Control and Estimation: A Unified Approach*, Prentice Hall Inc., 1990.

2.1.3.16 EC - 717 Antenna Theory and Design

L	-	T	-	P		
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Course Code	:	$EC - 717$
Course Name	:	*Antenna Theory and Design.*
Contact Hours per Week	:	*3(Four) Hours.*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Aim: To get an in-depth understanding on designing of varieties of antennas for a wide range of applications.

Objectives: Students shall be able to

- Explain the radiation mechanism and different parameters of an antenna.
- Understand the significance of antenna arrays.
- Design antenna for different applications.

Antenna Fundamentals and Definitions: Radiation mechanism - overview, Electromagnetic Fundamentals, Solution of Maxwell's Equations for Radiation Problems, Ideal Dipole, Radiation pattern, Beam solid angle, Directivity, Gain, Input impedance, Polarization, Bandwidth, Reciprocity, Equivalence of Radiation patterns, Equivalence of Impedances, Effective aperture, Vector effective length, Antenna temperature.

Antenna Arrays: Array factor for linear arrays, uniformly excited, equally spaced Linear arrays, pattern multiplication, directivity of linear arrays, non- uniformly excited -equally spaced linear arrays, Mutual coupling, multidimensional arrays, phased arrays, feeding techniques, perspective on arrays.

Wire Antennas: Traveling - wave antennas, Helical antennas, Biconical antennas, Principles of frequency independent Antennas, Rumsey's Principle, spiral antennas, and Log - Periodic Antennas, Yagi - Uda Antennas.

Aperture antennas: Huygen's Principle, Fourier Transform relation between aperture distribution and far field pattern, Slot Antenna, Babinet Principle and complementary antennas, Horn Antenna, Pyramidal Horn Antenna, Reflector Antenna-Flat reflector, Corner Reflector, Common curved reflector shapes, Di- electric lens and metal plane lens antennas. Lumeberg lens. Microstrip antenna: Feeding methods, transmission line & cavity models, Analysis and design of rectangular & circular microstrip antenna, Fundamental limitations in antennas.

Text Books:

1. J. D. Kraus, *Antennas*, 2/e, McGraw Hill Book Co., 1988.
2. C. A. Balanis, *Antenna Theory: Analysis and Design*, 3/e, John Wiley & Sons, 2005.
3. Thomas A. Milligan, *Modern Antenna Design*, 2/e, Wiley-IEEE Press, 2005.

Reference Books:

1. Jordan and Balmain, *Electromagnetic Wave and Radiating Systems*, John Wiley, 2002.
2. Yi Huang and Kevin Boyles, *Antennas: From Theory to Practice*, Wiley-IEEE Press, 2008.

2.1.3.17 EC - 718 Advanced Image Processing

L	-	T	-	P		
4	-	0	-	0	=	4

Course Code	:	$EC-718$
Course Name	:	*Advanced Image Processing.*
Contact Hours per Week	:	*4(Four) Hours.*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Aim: To get in-depth knowledge of various image processing algorithms and their applications.

Objective: Students shall be able to

- Explain the fundamentals of image processing.
- Discuss image transforms, restoration, segmentation, compression, and reconstruction.

Review of Digital Image Fundamentals: Elements of the image processing system, Digital image representation, Image acquisition, Image Sampling and quantization, point processing, histogram processing.

Image Transforms: 2 D-DFT, Cosine and Hadmard transform, Transform operations, smoothing and sharpening using frequency domain filters, Homomorphic filtering.

Image Restoration and segmentation: Image degradation/restoration process, noise models and filter types, geometric transforms, color image processsing, image segmentation, and classification techniques.

Image Compression and reconstruction: Compression and standards, interframe coding, image reconstruction from projections, back projection operator, projection theorem.

Text Books:

1. W. K. Pratt, *Digital Image Processing*, 1/e, Wiley, 2010.
2. R. C. Gonzalez and R. E. Woods, *Digital Image Processing*, 3/e, Pearson Education, 2008.
3. A. K. Jain, *Fundamentals of Digital Image Processing*, 2/e, Pearson Education, 2001.

Reference Books:

1. Joshi, *Digital Image Processing- An Algorithmic Approach*, PHI 2006.
2. Kenneth R. Castleman, *Digital Image processing*, PHI 2005.

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2.1.3.18 EC - 719 Computational Electromagnetics	4	-	0	-	0	=	4

Course Code	: $EC-719$
Course Name	: *Computational Electromagnetics.*
Contact Hours per Week	: *3(Four) Hours.*
Marks Distribution	: *Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: *3(Three) Hours.*

Aim: To familiarize the electromagnetic computational techniques which are used for microwave circuit simulation.

Objectives: Students shall be able to

- Explain computational methods used in electromagnetics.
- Describe the FDTD, FEM and MoM techniques.

Introduction to Computational Electromagnetics(CEM): Application of electromagnetics, Review of Basic electromagnetics, Overview of computational electromagnetics: The finite difference time domain (FDTD) method, Method of moments (MoM), The finite element method (FEM), Understanding boundary conditions, The CEM modeling process, Verification and validation, Convergence and extrapolation.

The finite difference time domain method: An overview of finite differences, A one-dimensional introduction to the FDTD, FDTD solution of the one-dimensional lossless transmission line problem, Numerical dispersion in FDTD simulations, The Courant stability criterion, The 2D FDTD algorithm, , Electromagnetic scattering problems, the scattered and total field formulation Including a source, Absorbing boundary conditions, The PML absorbing boundary condition The 3D FDTD algorithm, The Yee cell in 3D.

The method of moments: Introduction of MoM with an electrostatic example, Thin-wire electrodynamics- ics and the MoM, The method of weighted residuals, Electric and magnetic field integral equations, The Rao–Wilton–Glisson (RWG) element surface modeling, Modelling of homogeneous material bodies, Scattering from a dielectric sphere.

The finite element method: A one-dimensional introduction to the FEM, The transmission line model problem, Evaluation the elemental matrices, Improving and generalizing the FEM solution, The FEM in two dimensions: scalar and vector elements, Finite element solution of the Laplace equation in two dimensions, The Galerkin formulation, Simplex coordinates, The high-frequency variational functional, The null space of the curl operator and spurious modes, Vector elements, Waveguide eigenvalue analysis, Waveguide dispersion analysis.

Text Books:

1. David B. Davidson, *Computational Electromagnetics for RF and Microwave Engineering*, 2/e, Cam- bridge University Press, 2011.
2. Jianming Jin, *The Finite Element Method in Electromagnetics*, 2/e, John Wiley & Sons, 2010.
3. Walton C. Gibson, *The Method of Moments in Electromagnetics*, Chapman & Hall/CRC, 2008.

Reference Books:

1. Raj Mittra, *Computational Electromagnetics: Recent Advances and Engineering Applications*, Springer, 2014.
2. Umran S. Inan, Robert A. Marshall, *Numerical Electromagnetics: The FDTD Method*, Cambridge University Press, 2011.

2.1.3.19 EC - 720 Optical Communication Networks

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Course Code	: $EC-720$
Course Name	: *Optical Communication Networks.*
Contact Hours per Week	: *4(Four) Hours.*
Marks Distribution	: *Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: *3(Three) Hours.*

Aim: To get an in-depth understanding of the theoretical model and design of optical communication networking system based on given specifications.

Objectives: After completion of this course, students shall be able to

- Analyze and design optical components such as optical couplers, isolators, Mux, Demux etc.
- Discuss the Client Layers, Network hierarchy, routing and quality of service in an optical network.
- Estimate cost trade-offs in optical networks and discuss Statistical and Maximum Load, dimensioning Models.
- Design the transmission layer using: SDM/TDM/WDM.

Introduction to Optical Networks: Network architecture, Switching, first and second-generation optical networks, Optical Layer, transmission basics-fiber types, power loss, WDM technology, Optical Components: couplers, isolators and circulators, Multiplexers and Filters, Optical Amplifiers, optical sources, and detectors, switches and wavelength converters.

Optical Networks: SONET/SDH Networks, optical transport network, generic framing procedure, Ethernet, IP-routing and forwarding, quality of service, Multiprotocol Label Switching, Resilient Packet ring-QoS, node structure, fairness, Storage-Area Networks-fiber channels, WDM network elements: Optical Line Terminals, Optical Line Amplifiers, Optical Add/Drop Multiplexures-OADM Architectures, reconfigurable OADMs, optical cross-connects.

WDM Network Design: Cost Trade-Offs with an example, LTD and RWA Problems- Lightpath topology de- sign, Routing and Wavelength Assignment, Wavelength conversion, Dimensioning Wavelength –Routing Networks, Statistical Dimensioning Models-first passage model, blocking model, Maximum Load Dimensioning Modes-Offline Lightpath Requests and Online RWA in Rings.

Network Deployment Considerations: SONET/SDH Core Network, Architectural Choices for Next generation Transport Networks, Designing the Transmission Layer-Using SDM, TDM, WDM, unidirectional versus bidirectional WDM Systems, Long-Haul Network, and Metro Networks.

Text Books:

1. D. Hood, *Gigabit-capable Passive Optical Networks*,1/e, Wiely, 2012.
2. R. Ramaswami, K. N. Sivarajan and G. H. Sasaki, *Optical Networks: A Practical Perspective*, 3/e, Morgan Kaufmann Publishers, New Delhi: An imprint of Elsevier, 2010.
3. Thomas E. Stern, Georgios Ellinas, Krishna Bala, *Multiwavelength Optical Networks: Architectures, Design, and Control*, 2/e, Cambridge University Press, 2008.
4. D. Cameron, *Optical Networking*, 1/e, Wiley, 2001.

Reference Books:

1. Steven Shepard, *Optical Networking Crash Course*, 1/e, McGraw-Hill Professional, 2008.
2. Walter J. Goralski, *Sonet/SDH* , 3/e, McGraw-Hill/Osborne Media, 2004.
3. Daniel Minoli, Peter Johnson, Emma Minoli, *SONET-based Metro Area Networks* , 1/e, McGraw-Hill Professional, 2002.

2.1.3.20 EC - 721 Processor Architectures for VLSI

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Course Code	: $EC-721$
Course Name	: *Processor Architectures for VLSI.*
Contact Hours per Week	: *4(Four) Hours.*
Marks Distribution	: *Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: *3(Three) Hours.*

Aim: To get an in-depth understanding of VLSI implementation of DSP algorithms.

Objectives: After completion of this course, students shall be able to

- Explain specialized processor architectures for real-time systems.
- Discuss Mapping of algorithms to architectures.
- Achieve fault-tolerant DSP implementation.
- Explain system architecture exploration through heterogeneous system simulation.

Introduction to DSP processors: Introduction to Digital Signal Processing Systems, Iteration Bound, Pipelining and Parallel Processing, Retiming, Unfolding, and Folding. Systolic Architecture Design: Introduction, Systolic Array Design Methodology, FIR Systolic Arrays, Selection of Scheduling Vector.

Systolic Processor Design: Array Processors and Mapping, fundamental concepts and designs of systolic/wavefront, concurrent, and parallel VLSI array processors as platforms for high-performance signal processing. Design of Algorithms for VLSI Systolic Arrays, Regular Iterative Algorithms, and their Implementation on Processor Arrays.

Design and implementation of VLSI-Dsp System: Fast Convolution, Algorithmic Strength Reduction in Filters and Transforms, Pipelined Parallel Recursive and Adaptive Filters, Scaling and Roundoff Noise, Digital Lattice Filter Structures, Bit-Level Arithmetic Architectures, Redundant Arithmetic, Numerical Strength Reduction.

Specialized DSP processors, Heterogeneous simulation and Fault-tolerant processor arrays: Synchronous, Wave and Asynchronous Pipelines, Low-Power Design, Programmable Digital Signal Processors: Evolution and Features of Programmable DSP Processors, DSP Processors for Multimedia and Communications. Design and simulation of heterogeneous systems and scheduling for efficient implementation of DSP algorithms on multiprocessors systems. Computer-Aided Designs and automatic design tools for signal processing. Fault Tolerance in VLSI Signal Processing, Fault (error) detection, fault diagnosis, and fault recovery.

Text Books:

1. Keshab K. Parhi, *VLSI Digital Signal Processing Systems: Design and Implementation*, Wiley Inc., 1998.
2. K. J. Ray LIU and Kung Yao (Eds.), *High-Performance VLSI Signal Processing: Innovative Architectures and Algorithms, Vol. I - Algorithms and Architectures*, IEEE Press, 1998.

Reference Books:

1. S. Rao and T. Kailath, *Regular Iterative Algorithms and their Implementation on Processor Arrays*, Proceedings of the IEEE, 1988.
2. H. T. Kung, *Why Systolic Architectures?*, IEEE Computer, 1982.

2.1.3.21 EC - 722 Digital IC Design

L - T - P
4 - 0 - 0 = 4

Course Code	:	$EC - 722$
Course Name	:	*Digital IC Design.*
Contact Hours per Week	:	*4(Four) Hours.*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Aim: To get an understanding of the Synthesis, Optimization, Verification, and Testing of Digital Circuits.

Objectives: Students shall be able to

- Explain automated digital synthesis flow.
- Discuss the techniques for the verification and the testing of digital circuits.

CAD tool Flow: Introduction to Digital VLSI Design Flow Specification, High-level Synthesis, RTL Design, Logic Optimization, Verification and Test Planning, Design Representation, Hardware Specific Transformations.

High-Level Synthesis: Scheduling, Allocation and Binding: Problem Specification(Scheduling, Allocation and Binding), Basic Scheduling Algorithms (Time constrained and Resource Constrained), Allocation Steps: Unit Selection, Functional Unit Binding, Storage Binding, Interconnect Binding, Allocation Techniques: Clique Partitioning, Left-Edge Algorithm, Iterative Refinement.

Gate Level Synthesis and Optimization: Logic Optimization and Synthesis: Heuristic Minimization of Two-Level Circuits: Espresso, Finite State Machine Synthesis, Multi-Level Logic Synthesis, Multi-Level Minimization, Technology Mapping, Binary Decision Diagram: Introduction and construction, Reduction rules and Algorithms, ROBDDs, Operation on BDDs and its Algorithms, Representation of Sequential Circuits.

Verification and Testing: Model Checking: Introduction to Verification, Specification and Modelling, Model Checking Algorithm, Symbolic Model Checking, Automata and its use in Verification, Automata Theoretic Model Checking. Introduction to Digital Testing, Fault Simulation, and Testability Measures, Combinational Circuit Test Pattern Generation, Sequential Circuit Testing and Scan Chains, and Built-in Self-test (BIST).

Text Books:

1. G. De Micheli, *Synthesis and optimization of digital circuits*, Tata McGraw-Hill Education, 2003.
2. D. D. Gajski, N. D. Dutt, A. C.-H. Wu and S .Y.-L. Lin, *High-Level Synthesis: Introduction to Chip and System Design*, 1/e, Springer, 1992.
3. M. Huth and M. Ryan, *Logic in Computer Science modeling and reasoning about the system*, 2/e, Cambridge University Press, 2004.

References:

1. Bushnell and Agrawal, *Essentials of Electronic Testing for Digital, Memory, and Mixed-Signal Circuits*, Kluwer Academic Publishers, 2000.

2.1.2.22 **EC - 723 Silicon Photonics** L -T- P
4 - 0 - 0 = 4

Course Code	:	EC − 723
Course Name	:	*Silicon Photonics.*
Contact Hours per Week	:	*4(Four) Hours.*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Aim: To design Silicon Photonics (SiPh) technology-based Interferometer (MZI/MRR/Michelson) with suggested specifications for data-center interconnect and communication applications.

Objectives

- To recognize and explain Silicon Photonics (SiPh) as an emerging technology to meet the explosive bandwidth demand and computationally efficient systems
- To Model SiPh technology-based passive photonic devices such as strip waveguides, Y-branch, directional couplers, etc.
- To design the Layout of passive photonic devices on an open-source GDS-II platform, i.e., KLayout using SiEPIC tools and pdks
- To evaluate the performance of MZI/MRR/Michelson interferometers for interconnects and PIC applications with given specifications

Introduction to Silicon Photonics (SiPh): SiPh as the next fabless semiconductor industry, application of SiPh in data center and communication, technical challenges and state of the art, Opportunities in SiPh engineer as a career

Modeling and Design approach: Introduction to Mode solvers, Physical Layout: different physical layout tools, Introduction and application of KLayout (open-source) for GDS-II design. Introduction to Design workflow. Optical materials and waveguides: SoI, waveguides-slab waveguide, 1-D and 2-D mode profile calculations, compact models for waveguides, and waveguide loss.

SiPh-based Passive Devices: Design of Y-branch, strip waveguide grating, Directional Coupler, MZI, MRR, Bragg gratings filters, Lattice filter, Multiplexer/Demultiplexer

Design of SiPh-based Circuits on SoI: Optical Input/Output Devices: Grating and edge couplers, Lattice filter, Multiplexer/Demultiplexer using SiEPIC pdk on KLayout, DRC, Circuit simulation and characterization

Text Books:

1. Lukas Chrostowski and Michael Hochberg, ***Silicon Photonics Design: from Devices to Systems***, 1/e, 2016, Cambridge University Press, University Printing House, Cambridge CB2 8BS, UK

2. Slawomir Sujecki, ***Photonics Modeling and Design***, 1/e, 2015 CRC Press, Taylor and Francis Group, 6000 Broken Soud Parkway, NW, Suit 300.

3. Daryl Inniss and Roy Rubenstein, ***Silicon Photonics-Fuelling the Next Information Revolution,*** 1/e, 2016, Morgan Kaufmann, USA

4. David J. Lockwood, Lorenzo Pavesi, ***Silicon Photonics IV: Innovative Frontiers,*** *1/e, 2021, Springer Cham*

Reference Books/Journals:

1. Lorenzo Pavesi, David J. Lockwood, ***Silicon Photonics***, *Topics in Applied Physics (TAP, volume 94), 1/e,* 2004, Springer Berlin, Heidelberg

2. Graham T. Reed and Andrew P. Knights, ***Silicon Photonics: An Introduction***, 1/e, 2004, Wiley

3. David J. Lockwood and Lorenzo Pavesi, ***Silicon Photonics II: Components and Integration***: 119 (Topics in Applied Physics), 1/e, 2010, Springer

4. IEEE Journals of Photonics Technology Letters, JLT, Sec. Topics in Quantum Electrons etc.

Tools:

1. Matlab ,Comsol Multiphysics(https://www.istem.gov.in/rd-infrastructure-map/software-through-istem, visited 26.08.2022), Ansys Lumerical

2. Python, KLayout, SiEPIC tools, and pdk (https://github.com/SiEPIC, visited 26.08.2022)

3. Virtual Simulation Laboratory https://manufacturingworkforce.org/courses/course-v1:VM-Lab+IPSL+2021/about (visited on 24.09.2022)

2.1.3.22 EC - 724 PIC Design

L	T	-P		
4	-0	-0	=	4

Course Code	: $EC-724$
Course Name	: *PIC Design*
Contact Hours per Week	: *4(Four) Hours.*
Marks Distribution	: *Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: *3(Three) Hours.*

Aim: To design Photonic Integrated Circuit with suggested specifications for data-center interconnect and communication applications.

Objectives

•To recognize and explain Photonic Integrated Circuits on SoI along with electronics as an emerging technology to meet the explosive bandwidth demand and computationally efficient systems

•To Model Passive and Active PICs on SOI platform using SiPh technology

•To design the Layout of passive and active photonic devices on an open-source GDS-II platform, i.e., KLayout using SiEPIC tools and pdks

• To evaluate the performance of PIC for data center and communication applications with given specifications

Introduction to Photonic Integrated Circuits (PICs): Review of SiPh technology and role of PIC along with Integrated electronic Circuits, Planar Waveguide and its types on SoI, Waveguide design, calculation of the effective index, compact model of a slap-waveguide.

Fundamental Building Blocks of PICs: Design of Y-branch, Directional Couplers, Grating, and Edge Couplers, Taper, bend waveguide.

Functional Device and Circuits for PICs: MZI: Derivation of Transfer Function of MZI, Michelson Interferometer, Derivation of FSR, Application of MZIs; Microring Resonator (MRR): Transfer Function of MRR, Michalson, Derivation of FSR, Application of MRRs; Plasma-dispersion effect and pn-junction phase shifter, photodetector on SoI

Introduction to SIEPIC tools and PDKs: CMOS fabrication steps for passive PICs, GDS-II Layout on KLayout design platform, interface with SiEPIC tools, Process Design kits (pdk) associated with e-beam pdk, application of e-beam pdk in designing MZI, MRR and other functional Devices. Design rule check and simulation. SiPh-based Transceiver.

Text Books:

1. Lukas Chrostowski and Michael Hochberg, ***Silicon Photonics Design: from Devices to Systems***, 1/e, 2016, Cambridge University Press, University Printing House, Cambridge CB2 8BS, UK, 2016

2. Richard Osgood jr.,Xiang Meng, ***Principles of Photonic Integrated Circuits: Materials, Device Physics, Guided Wave Design***, 1/e, 2021, Springer

3. José Capmany; Daniel Pérez, ***Programmable Integrated Photonics***, 1/e, 2020, Oxford University Press.

4. David J. Lockwood and Lorenzo Pavesi, ***Silicon Photonics III: Components and Integration: 119 (Topics in Applied Physics)***, 1/e, 2018, Springer

Reference Books/Journals:

1. Lorenzo Pavesi, David J. Lockwood**, Silicon Photonics, Topics in Applied Physics (TAP, volume 94),** 1/e, 2004, Springer

Berlin, Heidelberg

2. Graham T. Reed and Andrew P. Knights, **Silicon Photonics: An Introduction**, 1/e, 2004, Wiley

3. David J. Lockwood and Lorenzo Pavesi, **Silicon Photonics II: Components and Integration**: **119 (Topics in Applied Physics)**, 1/e, 2010, Springer

4. IEEE Journals of Photonics Technology Letters, JLT, Sec. Topics in Quantum Electrons etc.

Tools:

1. Matlab ,Comsol Multiphysics(https://www.istem.gov.in/rd-infrastructure-map/software-through-istem, visited 26.08.2022), Ansys Lumerical

2. Python, KLayout, SiEPIC tools, and pdk (https://github.com/SiEPIC, visited 26.08.2022)