Agnel Charities'

Fr. C. Rodrigues Institute of Technology

Sector 9A, Vashi, Navi Mumbai, 400703, Maharashtra, India

www.fcrit.ac.in

An Autonomous Institute Affiliated to the University of Mumbai

Department of Electronics & Telecommunication Engineering

Curriculum Structure and

Third Year Syllabi

Prepared by : Board of Studies for Department of Electronics & Telecommunication Engineering

Approved By: Academic Council of Fr. C. Rodrigues Institute of Technology

Revision: 2024.1

Effective from: AY 2024-25

PREAMBLE FROM DEAN (ACADEMICS)

Accelerating Towards Excellence: Unveiling a New Era in Education

Dear Students, Faculty, and Stakeholders,

It is with great pleasure and anticipation that we introduce the newly designed curriculum for autonomy at Agnel Charities' Fr. C. Rodrigues Institute of Technology. This pioneering initiative aims to revolutionize engineering education, ensuring our graduates are equipped with not only technical prowess but also the holistic skills necessary for thriving in today's dynamic professional landscape.

1. **Purpose of Autonomy:** Our commitment to autonomy is rooted in the imperative to bridge the gap between academia and industry. We envision education as a catalyst for individual growth, fostering self-sustainability and enhancing employability. Through our curriculum, westrive to nurture engineers who not only excel in their fields but also contribute meaningfullyto society.

2. **Curriculum Design: A Top-to-Down Approach:** Our curriculum is meticulously crafted with a top-to-down approach, encompassing all 12 attributes of Program Outcomes mandated by regulatory bodies. Emphasizing a blend of theoretical knowledge and practical application, it is designed to cultivate well-rounded professionals capable of tackling real-world challenges with confidence and competence.

3. **Alignment with National Education Policy-2020:** In adherence to the guidelines laid out in the National Education Policy-2020, our curriculum embodies a multidisciplinary approach, offering a diverse array of core and elective courses. It integrates hands-on learning experiences such as mini and major projects, skill-based labs, and one-semester internships to nurture innovation and problem-solving skills. Additionally, the inclusion of value-added courses, honours, and minors ensures a comprehensive educational journey tailored to individual interests and aspirations.

4. **Opportunities for Teachers in Innovation:** We recognize the pivotal role of our faculty in shaping the educational experience. Our curriculum provides ample opportunities for teachers to innovate in teaching-learning methodologies and evaluation techniques. Throughcontinuous professional development programs and collaborative platforms, we empower our educators to experiment with innovative pedagogies, leverage technology for enhanced learning outcomes, and implement novel assessment strategies. By fostering a culture of innovation among our faculty, we aim to enrich the learning experience and inspire a passionfor lifelong learning among our students.

As we embark on this transformative journey, we invite all stakeholders to join us in shaping the futureof engineering education. Together, let us strive towards excellence, innovation, and societal impact.

Sincerely,

Dean of Academics Agnel Charities' Fr. C. Rodrigues Institute of Technology

PREAMBLE FROM CHAIRPERSON (BoS)

Dear Students, Faculty, and Stakeholders,

It is with great pleasure and anticipation that we introduce the newly designed curriculum for autonomy at the Department of Electronics & Telecommunication (EXTC) engineering, Agnel Charities' Fr. C. Rodrigues Institute of Technology. This pioneering initiative aims to adapt to changing needs of the society, foster excellence, and drive innovation, thereby contributing to the nation's technological advancement and global competitiveness.

The Department has followed a top-down approach, for curriculum design. The steps include consultation with stakeholders; mapping outcomes to courses; setting learning objectives which are clear and measurable; designing the content aligned with the learning objectives; selection of instructional material, activities, and assessment tools to support the alignment, integration of experiential learning through projects, skill laboratories, internships, and industry collaboration; and set the stage for continuous evaluation and improvement. The consultation with Industry partners has enabled to identify requirements of Industry and to introduce four Honours/minor tracks, namely, VLSI, IoT & Embedded Systems, AIML and Network Security. The current trends in Industry have been taken into consideration while designing the content of core courses, laboratory courses, program electives as well as Honours/minor courses. The recent impetus to the semiconductor program in India has motivated us to include courses like Electronic Devices & Circuits, CMOS Design, ASIC Design, System on Chip Design etc which will certainly make our graduates ready for the semiconductor industry.

In alignment with the transformative vision laid out in the National Education Policy (NEP) 2020, our curriculum is designed to empower students with a comprehensive understanding of core domains like electronics, communication, and signal processing. Through multi-disciplinary courses, skill laboratories and exclusively designed laboratory courses, students develop the skills required to address complex challenges. Practical engineering aspects like Image Processing & Machine Vision, Antenna Design, High Frequency Communication etc are introduced through stand-alone laboratory courses. The curriculum caters to diversity in learners' choices by offering program electives in different fields like Microwave engineering/ Optical Fiber Communication/ Satellite & nano-satellite Communication/Digital TV Engineering etc.

In the autonomous curriculum, teachers have numerous opportunities to innovate and enhance the educational experience for students. Teachers actively participate in designing the curriculum, tailoring it to suit the needs of students and aligning it with industry trends and emerging technologies. Teachers can engage in research and development activities and offer Internships to explore new areas. Teachers can foster partnerships with industry organizations to enrich the curriculum with industry-relevant projects, internships, and guest lectures. Overall, autonomy in curriculum aims to empower the teachers to play a central role in shaping the learning experiences of students, in the field of Electronics & Telecommunication Engineering.

Thus, by nurturing creativity, resilience, and a spirit of inquisitiveness, we aspire to empower our graduates to become leaders, innovators, and global ambassadors of excellence in the field of electronics and telecommunication engineering. As we embark on this transformative journey, we invite all stakeholders to join us in shaping the future of engineering education. Together, let us strive towards excellence, innovation, and societal impact.

Sincerely,

Chairperson, Board of Studies-Electronics & Telecommunication Engineering,
Agnel Charities' Fr. C. Rodrigues Institute of Technology

Contents

B. Credit Structure

1. B. Tech in Electronics & Telecommunication Engineering											
Type of Course	**Semester-wise Credit Distribution**									**FCRIT Credit Distribution**	**DTE Credit Distribution**
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**Total**		
Basic Science Course (BSC)	08	08	--	--	--	--	--	--	**16**	**18**	**14-18**
Basic Science Laboratory Course (BSL)	01	01	--	--	--	--	--	--	**02**		
Engineering Science Course (ESC)	05	02	--	--	--	--	--	--	**07**	**16**	**12-16**
Engineering Science Laboratory Course (ESL)	04	05	--	--	--	--	--	--	**09**		
Program Core Course (PCC)	--	--	14	13	06	03	03	--	**39**	**50**	**44-56**
Laboratory Course (LBC)	--	--	02	03	02	02	02	--	**11**		
Program Elective (PEC)	--	--	--	--	03	03	06	03	**15**	**15**	**20**
Multidisciplinary Minor (MDM)	--	--	03	03	03	04	—	--	**13**	**13**	**14**
Multidisciplinary Laboratory Course (MDL)†	--	--	--	--	01	--	--	--	**01**	**01**	
Open Elective (OEC)	--	--	--	--	--	--	03	03	**06**	**06**	**08**
Skill Enhancement Course (SEC)	01	01	--	--	--	--	--	--	**02**	**08**	**08**
Skill Based Laboratory (SBL)	--	--	02	02	--	02	--	--	**06**		
Ability Enhancement Course (AEC)	--	03	--	--	02	--	--	--	**05**	**05**	**04**
Humanities Social Sciences and Management (HSS)	--	--	02	--	02	--	02	--	**06**	**06**	**04**
Indian Knowledge System (IKS)	--	02	--	--	--	--	--	--	**02**	**02**	**02**
Value Education Course (VEC)	02	--	--	02	--	--	--	--	**04**	**04**	**04**
Experiential Learning Course (ELC)	--	--	--	--	--	02	--	--	**02**	**02**	**04**
Mini Project (MNP)	--	--	01	01	01	01	--	--	**04**	**10**	**04**
Major Project (MJP)	--	--	--	--	--	--	02	04	**06**		
Internship (INT)	--	--	--	--	--	--	--	08	**08**	**08**	**12**
Liberal Learning Course (LLC)	--	--	--	--	--	02	--	---	**02**	**02**	**04**
Total Credits	**21**	**22**	**24**	**24**	**20**	**19**	**18**	**18**	**166**	**166**	**160-176**

C Curriculum Structure and Examination Scheme for B. Tech in Electronics & Telecommunication Engineering

with Effect from AY 2024-2025
Curriculum Structure – TY Semester-V

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
ECPCC509	Signals and Systems	3	--	--	3	--	--	3
ECPCC510	Digital Communication	3	--	--	3	--	--	3
XXMDM503	--	3	--	--	3	--	--	3
ECPEC501Y	Program Elective Course-I	3	--	--	3	--	--	3
ECLBC506	HDL Programming Laboratory	--	2	--	--	1	--	1
ECLBC507	Digital Communication Laboratory	--	2	--	--	1	--	1
ECLBC508	Electromagnetics & Antenna Laboratory	--	2	--	--	1	--	1
AEC502	Professional Communication and Ethics-II	1	2	--	1	1	--	2
ECMNP503	Mini Project-2A	--	3	--	--	1	--	1
HSS502	Entrepreneurship	2	--	--	2	--	--	2
	Total	**15**	**11**	**--**	**15**	**5**	**--**	**20**

NOTE: Students who choose not to pursue Honours or Minor are welcome to register for the initial two courses of the fifth and sixth semesters' Honours or Minor track in 'Audit' mode (AU). This allows them to explore the course material without the expectation of earning a letter grade. Upon fulfilling the requirements in 'Audit' mode, their participation will be acknowledged on the grade sheet. Audit courses are excluded from grade point averages and have no impact on SGPI/CGPI calculations. For more information on Honours and Minor track courses, please refer to the Institute Handbook for Honours/Minor/Honours in Research degree programs.

List of Courses under Program Elective Course-I (ECPEC501Y)

Course Code	Course Name
ECPEC5011	Electromagnetic Wave Theory
ECPEC5012	Computer Communication Network
ECPEC5013	Digital VLSI#
ECPEC5014	Robotics

#: Students who have opted for VLSI as their Honours track, can not opt for Digital VLSI as Program Elective Course-I.

Examination Scheme – TY Semester-V

Course Code	Course Name	Examination Scheme					Total
		In-Semester Assessment$		End Sem Exam (ESE)	Exam Duration for Theory (in Hrs)		
		Continuous Assessment	Mid-Sem Exam		Mid - Sem	End-Sem	
ECPCC509	Signals and Systems	20	30	50	1.5	2	100
ECPCC510	Digital Communication	20	30	50	1.5	2	100
XXMDM503	--	20	30	50	1.5	2	100
ECPEC501Y	Program Elective Course-I	20	30	50	1.5	2	100
ECLBC506	HDL Programming Laboratory	25	--	25	--	--	50
ECLBC507	Digital Communication Laboratory	25	--	25	--	--	50
ECLBC508	Electromagnetics & Antenna Laboratory	25	--	25	--	--	50
AEC502	Professional Communication and Ethics-II	50	--	--	--	--	50
ECMNP503	Mini Project-2A	50	--	--	--	--	50
HSS502	Entrepreneurship	50	--	--	--	--	50
	Total	**305**	**120**	**275**	--	--	**700**

$Please refer to the Curriculum Book of respective departments for guidelines on in-semester assessments for both theory and laboratory courses.

Curriculum Structure – TY Semester-VI

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
ECPCC611	Discrete Time signal Processing	3		--	3	--	--	3
XXMDM604	--	4		--	4	--	--	4
ECPEC602Y	Program Elective Course-II	3	--	--	3	--	--	3
ECLBC609	Discrete Time signal Processing Lab	--	2	--	--	1	--	1
ECSBL603	Image Processing and Machine Vision Laboratory	--	4	--	--	2	--	2
XXMDL601	--	--	2	--	--	1	--	1
ECMNP604	Mini Project-2B	--	3	--	--	1	--	1
ELC601	Research Methodology	2	--	--	2	--	--	2
LLC601Y*	Liberal Learning Course	2	--	--	2	--	--	2
	Total	**14**	**11**	--	**14**	**5**	--	**19**

NOTE: Students who choose not to pursue Honours or Minor are welcome to register for the initial two courses of the fifth and sixth semesters' Honours or Minor track in 'Audit' mode (AU). This allows them to explore the course material without the expectation of earning a letter grade. Upon fulfilling the requirements in 'Audit' mode, their participation will be acknowledged on the grade sheet. Audit courses are excluded from grade point averages and have no impact on SGPI/CGPI calculations. For more information on Honours and Minor track courses, please refer to the Institute Handbook for Honours/Minor/Honours in Research degree prorams.

***Liberal Learning Course:**

Every student should take Liberal Learning Course for Semester VI. Students can take this course from the following list of Liberal Learning Courses.

Liberal Learning Courses	
Course Code	**Course Name**
LLC6011	**Art of Living**
LLC6012	**Yoga and Meditation**
LLC6013	**Health and Wellness**
LLC6014	**Diet and Nutrition**
LLC6015	**Personality Development**

List of Courses under Program Elective Course-II (ECPEC602Y)

Course Code	Course Name
ECPEC6021	Random Signal Analysis
ECPEC6022	Optical Fiber Communication
ECPEC6023	Analog VLSI[#]

#: Students who have opted for VLSI as their Honours track, can not opt for Digital VLSI as Program Elective Course-II.

Examination Scheme – TY Semester-VI

Course Code	Course Name	Examination Scheme					Total
		In-Semester Assessment$		End Sem. Exam (ESE)	Exam Duration for Theory (in Hrs)		
		Continuous Assessment	Mid-Sem Exam		Mid-Sem	End-Sem	
ECPCC611	Discrete Time signal Processing	20	30	50	1.5	2	100
XXMDM604	--	20	30	50	1.5	2	100
ECPEC602Y	Program Elective Course-II	20	30	50	1.5	2	100
ECLBC609	Discrete Time signal Processing Lab	25	--	25	--	--	50
ECSBL603	Image Processing and Machine Vision Laboratory	50	--	50	--	--	100
XXMDL601	--	25	--	25	--	--	50
ECMNP604	Mini Project-2B	50	--	50	--	--	100
ELC601	Research Methodology	50	--	--	--	--	50
LLC601Y	Liberal Learning Course	50	--	--	--	--	50
	Total	**310**	**90**	**300**	--	--	**700**

$Please refer to the Curriculum Book of respective departments for guidelines on in-semester assessments for both theory and laboratory courses.

H. Third Year Syllabi

Course Type	Course Code	Course Name	Credits
PCC	ECPCC509	SIGNALS AND SYSTEMS	03

Examination Scheme					
Distribution of Marks			**Exam Duration (Hrs.)**		**Total Marks**
In-semester Assessment		**End Semester Examination (ESE)**			
Continuous Assessment	**Mid-Semester Exam (MSE)**		**MSE**	**ESE**	
20	30	50	1.5	2	100

Pre-requisite:

1. ECPCC405 Engineering Mathematics-IV

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of Solutions
4. PO6: The Engineer & Society
5. PO8: pIndividual & team work

Course Objectives:

1. To introduce the concept of sampling for band limited signals.
2. To familiarise the students with discrete time signals, their representation, types and operation on them.
3. To impart knowledge of types of discrete time systems and explain the concept of convolution in context of Linear Time Invariant systems and their interconnections.
4. To teach the principles of auto-correlation, cross-correlation, their analogy with convolution, and to explain energy spectral density (ESD), power spectral density (PSD), and their relationships with auto-correlation.
5. To equip students with the ability to apply the z-Transform and its inverse in analysing discrete-time signals and systems, understand system stability and causality.
6. To guide students to analyse discrete-time signals and systems using Fourier Transform, understand its properties and limitations and evaluate system responses to aperiodic signals and white noise.
7. To educate the students about the contribution of poles and zeros in the computation of magnitude and phase response of a given system and guide them in understanding their significance while designing frequency selective filters.

Module	Details	Hrs.
	Course Introduction Overview of Continuous time signals, Real time signals such as communication, satellite, biomedical etc., Single dimension and multidimensional signals, Open and closed loop systems in real time, Need of representation of data in mathematical form and processing them with the help of systems.	**01**
01.	**Introduction to Discrete Time signals** ***Learning Objective:*** *1. To introduce sampling theorem for band limited signals* *2. To educate the students about types of discrete time signals and various operations on them*	**7-8**
	Contents: Revision of Continuous time Signals and Sampling theorem* Sampling Theorem: Sampling of band limited signals Representation of DT Signals: Definition, Basic Elementary signals - exponential, sine, step, impulse, ramp. Operations on signals: Amplitude Scaling, Time Shifting, Reversal, Time Scaling, Addition, Subtraction, Multiple operation on single signal Classification of signals: Even and odd signals, periodic and nonperiodic signals, deterministic and non-deterministic signals, energy and power signals.	
	Self-Learning Topics:	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply mathematical techniques represent classify discrete time signals and formulate complex signals using elementary signals (PI 1.1.3)(PI 2.1.3)* *LO 1.2: Apply fundamental engineering concepts to sample band limited signals and analyse aliasing errors (PI 1.3.1) (PI 2.4.3)*	
02.	**Time domain analysis of Discrete Time systems** ***Learning Objective:*** *To introduce the concept of convolution for obtaining the output of an LTI system and their interconnections*	**7-8**
	Contents: Revision of Continuous time Systems and Convolution integral* Systems and Classification of systems: System Representation, system with and without memory, causal and non-causal system, linear and nonlinear system, time invariant and time variant system, stable system. Linear Time Invariant (LTI) systems: Representation of systems using differential /difference equation, Impulse, step and exponential response, System Stability and Causality.	

	Use of convolution sum for analysis of LTI systems, properties of convolution sum, impulse response of interconnected systems.	
	Self-Learning Topics:	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply fundamental transforms to analyse continuous time signals in the Laplace domain (PI 1.1.2)* *LO 2.1: Apply the concept of convolution to determine the response of an LTI systems and analyse its behavior. (PI 2.4.1.)(PI 1.4.1)* *LO 2.2: Test the given system for stability and causality based on the impulse response and system equation. (PI 2.4.4)*	
03.	**Correlation and Spectral Density** ***Learning Objective:*** 1. *To educate the students about the use of correlation for finding similarity in signals.* 2. *To explain the significance of Spectral density for Energy and Power signals*	**4-5**
	Contents: Auto-correlation, cross correlation, analogy between correlation and convolution, energy spectral density, power spectral density, relation of ESD and PSD with auto-correlation.	
	Self-Learning Topics:	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Use contemporary engineering techniques such as Autocorrelation to gain insight into the Spectral Density of real time discrete time signal (PI 2.4.2), (PI 6.1.1)* *LO 3.2: Apply engineering mathematics to obtain the similarity between two signals using cross correlation (PI 1.4.1)* *LO 3.3: Analyze the characteristics of random signals using autocorrelation (PI 2.1.3)*	
04.	**z-Transform and Discrete time LTI systems** ***Learning Objectives:*** 1. *To educate the students about Mapping between S-domain and z-domain along with the Concepts Region of Convergence* 2. *To guide the students to perform mathematical analysis discrete time systems using z- transform*	**7-8**
	Contents: z-Transform: Need of z-Transform, z-Transform of finite and infinite duration sequences, Concept of Region of Convergence, z-Transform properties, Standard z-transform pairs, relation between z-Transform and discrete time Fourier Transform, one sided z-Transform. Inverse z-Transform: Partial Fraction method only. Analysis of discrete time LTI systems using z-Transform: Systems characterized by Linear constant coefficient difference equation,	

	Transfer Function, plotting Poles and Zeros of a transfer function, causality and stability of systems, Total response of a system.	
	Self-Learning Topics:	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Compute the z- transform of a given discrete time function and estimate its ROC (PI 1.1.2)* *LO 4.2: Apply the properties of z- transform to compute the z-transform of discrete time signals (PI 1.3.1)* *LO 4.3: Identify appropriate impulse responses for stability and causality in the z-domain (PI 2.1.2)* *LO 4.4: Analyse a given system collaboratively by identifying mathematical assumptions necessary to allow modelling of a discrete time system for satisfying the given criteria. (PI 2.3.2)(PI 8.3.1)*	
05.	**Discrete-Time Fourier Transform** *Learning Objective/s:* 1. *To educate the students about use of the limited form of Z transform for spectral analysis of Discrete time signals and systems.* 2. *To guide students in carrying out frequency domain analysis of discrete time signals and systems using Discrete Time Signal Processing.*	**6-7**
	Contents: Fourier transform of non-periodic functions, Properties of Fourier Transform, Relation between DTFT and Z transform: Limitations of Fourier Transform, Inverse Fourier Transform, Analysis of LTI Discrete Time System Using Discrete Time Fourier Transform, Response to Aperiodic Input Signals, Response to white noise.	
	Self-Learning Topics: *Fourier transforms of Periodic function*	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Apply mathematical transforms to obtain the frequency domain representations of discrete time non periodic functions. (PI 1.1.2)* *LO 5.2: Apply Dirichlet's conditions and the Gibbs Phenomenon (PI 1.4.1)* *LO 5.3: Analyse the discrete time systems in frequency domain using Fourier transform (PI 2.4.1)* *LO 5.4: Use DTFT properties to collaboratively comprehend the frequency domain behaviour of discrete real time time signals and systems (PI 2.1.2)(PI 8.3.1)(PI 6.1.1)*	
06.	**LTI systems as frequency-selective filters** ***Learning Objective/s:*** 1. ***To introduce the geometrical method of computation of magnitude and phase response.***	**6-7**

	2. ***To guide the students in designing frequency selective filters using Pole zero placement.*** 3. ***To introduce the significance of Minimum phase and Maximum Phase systems.***	
	Contents: Geometric method of computation of Magnitude and Phase Response, Transfer function of low pass, high pass, notch, comb, all-pass filters, and digital resonators (using Pole - Zero placement), Minimum Phase and Maximum Phase Systems.	
	Self-Learning Topics:	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Apply engineering mathematics and computations to analyse Discrete time systems in the transform domain (PI 2.4.1)* *LO 6.2: Obtain the transfer function for a given frequency selective response using pole zero placement (PI 2.4.2)(PI 3.3.3)*	
	Course Conclusion	**01**
	Total	**45**

* No questions should be asked on these topics during the evaluation

Performance Indicators:

P.I. No.	**P.I. Statement**
1.1.2	Apply mathematical transforms to solve problems
1.1.3	Apply advanced mathematical techniques of computer and information science to describe/solve/construct a mathematical model of a system.
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1.	Apply concepts of electronics and communication engineering and accepted practice areas to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.3.2	Identify assumptions (mathematical and physical) necessary to allow modelling of a system at the level of accuracy required.
2.4.1	Apply engineering mathematics and computations to solve mathematical models.
2.4.2	Produce and validate results through skilful use of contemporary engineering techniques.
2.4.3	Identify sources of error in the solution process, and limitations of the solution.
2.4.4.	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis.

3.3.3 Identify relevant data from the given resources and arrive at a best fitting design solution for particular specifications.

6.1.1 Identify social, environmental and health related issues with the help of relevant viewpoints from stakeholders and propose engineering solutions.

8.3.1 Present results as a team, with smooth integration of contributions from all individual efforts

Course Outcomes: A learner will be able to -

1. Classify and perform time domain operations on different types of discrete time signals.
2. Classify discrete time systems and perform time domain analysis of Linear Time Invariant systems.
3. Analyse discrete time LTI signals and systems in transform domain for stability and causality.
4. Analyse signals and systems in the frequency domain using Fourier Transform, including the concepts of Correlation and Power Spectral Density.
5. Design and analyse Frequency selective filters using pole zero plots.

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECPCC509.1	3	3										
ECPCC509.2	3	3										
ECPCC509.3	3	3						2				
ECPCC509.4	3	3				2		2				
ECPCC509.5	3		2									
Average	3	3	2			2		2				

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. Nagoor Kani, “Signals and Systems”, Tata McGraw Hill, Third Edition, 2011.
2. B.P. Lathi, “Principles of Linear Systems and Signals”, Oxford, Second Edition, 2010.
3. S. L. Nalbalwar, A. M. Kulkarni and S. P. Sheth, “Signals and Systems”, Synergy Knowledgeware, 2016.
4. Proakis JG, Manolakis DG. “Digital Signal Processing–Principles, Algorithms Applications”, Pearson Education, Prentice Hall, 4th Edition, 2007.

Reference Books :

1. Simon Haykin and Barry Van Veen, “Signals and Systems”, John Wiley and Sons, Second Edition,2004.

2. Hwei. P Hsu, “Signals and Systems”, Tata McGraw Hill, Third edition, 2010
3. V. Krishnaveni and A. Rajeshwari, “Signals and Systems”, Wiley-India, First Edition 2012.
4. NarayanaIyer, “Signals and Systems”, Cenage Learning, First Edition 2011.
5. Michael J Roberts, “Fundamentals of Signals and systems”, Tata McGraw Hill, special Indian Economy edition, 2009.
6. Rodger E Ziemer, William H. Tranter and D. Ronald Fannin, “Signals and Systems”, Pearson Education, Fourth Edition 2009.
7. Alan V. Oppenhiem, Alan S. Willsky and S. Hamid Nawab, “Signals and Systems”, Prentice-Hall of India, Second Edition, 2002

Other Resources :

1. Dr. K.N. Hari Bhat, Digital Communication, 2nd ED. Pearson Education.
2. Sanjay Sharma, Signals and Systems, With MATLAB, Katson Books
3. Charles Phillips, John Parr, Eve Riskin, Signals, systems and Transforms, Pearson.
4. https://ocw.mit.edu/resources/res-6-008-digital-signal-processing-spring-2011/studymaterials

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

Suggested breakup of distribution

a) MCQ test strictly as per GATE exam pattern / level): 05 Marks
b) Class test: 05 Marks
c) Design Assignment: 05 Marks OR Think Pair share Design activity: 05 Marks
d) Regularity and active participation: 05 Marks

2.Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20% to 30% weightage, and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Type	Course Code	Course Name	Credits
PCC	ECPCC510	Digital Communication	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. ECPCC304 Digital circuit design
2. ECPCC405 Engineering Mathematics-IV
3. ECPCC406 Linear Integrated circuits
4. ECPCC407 Principles of Communication

Program Outcomes addressed:

1. PO 1: Engineering knowledge
2. PO 2: Problem analysis
3. PO 3: Design/Development of Solutions
4. PO 4: Conduct investigations of complex problems
5. PO 11: Life-long learning

Course Objectives:

1. To familiarize the basics of information theory and source coding.
2. To exhibit various error control codes
3. To acquaint different digital modulation and demodulation techniques
4. To describe baseband system and its application

Module	Details	Hrs.
	Course Introduction This course is designed to introduce the fundamental concepts and techniques used in the transmission of information in digital form. As digital systems dominate today's communication landscape—from mobile phones to satellite systems—the knowledge gained here will help students to understand how these technologies work and enable them to apply that knowledge in real-world scenarios.	**01**
01.	**Information Theory and Source Codes** ***Learning Objective:*** • ***To introduce source coding techniques.*** • ***To facilitate understanding of information theory in Digital Communication Systems.***	**05**

	Contents: Block diagram of digital communication system, Information content of a source symbol, Source entropy, mutual entropy, Average information rate, AWGN channel, and Shannon Hartley channel capacity theorem. Introduction of source code, Huffman code, Shannon-Fano code, Lempel Ziv coding	
	Self-Learning Topics: ***Prefix codes***	
	Learning Outcomes: *A learner will be able to* *LO 1.1 Apply the fundamental concept of information theory to understand the importance of its characteristics in digital communication systems. (P.I.-1.3.1)* *LO 1.2 Apply concepts of source entropy and average information rate to evaluate the efficiency of a communication system. (P.I.-1.4.1)* *LO 1.3 Extract desired understanding of source coding techniques such as Huffman, Shannon Fano codes and draw conclusions based on the objectives and limitations to generate highly efficient code bit (PI: 2.4.4)*	
02.	**Channel Coding Techniques**	**12**
	Learning Objective: • ***To help learners understand the fundamentals of channel encoding and its performance metrics to analyze linear block codes and cyclic code.*** • ***To develop learner's understanding on convolutional codes using state diagrams, code trees, and trellis diagrams for efficient error correction.***	
	Contents: Need for channel encoding, redundancy, code rate, code efficiency and hamming bound. Linear block codes, cyclic codes. Convolution codes: State diagram, code tree, trellis diagram. Decoding of Convolutional codes using Viterbi algorithm. Application of channel coding techniques.	
	Self-Learning Topics: ***Turbo codes***	
	Learning Outcomes: *A learner will be able to* *LO 2.1 Apply the concept of error detection and error correction capability to understand the importance of its characteristics in digital communication systems. (P.I.- 1.3.1)* *LO 2.2 Apply engineering mathematics and computations to solve mathematical models relevant to channel coding and decoding techniques such as cyclic code, convolution codes, etc. (P.I.-2.4.1)* *LO 2.3 Compare different channel coding techniques based on the performance parameters. (P.I. 2.2.4)*	
03.	**Pulse Shaping for Optimum Transmission**	**04**
	Learning Objective: • ***To analyze and implement line coding technique in baseband digital transmission.*** • ***To help learners compare interferences in Baseband PAM Transmission.***	

	Contents: Line codes and their desirable properties, PSD of digital data. Baseband PAM transmission: Concept of inter channel and inter symbol Interference, eye pattern. Concept of equalizer to overcome ISI, Nyquist's Criterion for distortion less transmission. Duo-binary encoding and modified duo-binary encoding	
	Self-Learning Topics: ***Types of Equalizers.***	
	Learning Outcomes: *A learner will be able to* *LO 3.1 Compare different Line Codes/ different types of interference in digital communication systems. (P.I.-2.2.4)* *LO 3.2 Select the best line coding technique with minimum bandwidth as a design objective for a given data. (PI- 3.1.6)* *LO 3.3 Represent graphically the types of lines codes for a given data (PI- 4.3.3)* *LO 3.4 Develop ability to independently learn the types of equalizers. (P.I. 11.1.3).*	
04.	**Digital Modulation Techniques**	**10**
	Learning Objectives: *To teach various Binary and M-ary Modulation Techniques.*	
	Contents: Binary modulation techniques: BASK, BFSK, BPSK, M-ary Modulation techniques: QPSK, M-ary PSK, MSK, M-ary FSK, QAM, DPSK and DEPSK, probability of error in modulation schemes.	
	Self-Learning Topics: ***GMSK***	
	Learning Outcomes:	
	A learner will be able to *LO 4.1: Compare different digital modulation Schemes (P.I.-2.2.4)* *LO 4.2: Represent graphically the digital modulation techniques such as QPSK, M-ary PSK, M-ary FSK, MSK, M-ary QAM, and DPSK/DEPSK, for a given data (PI- 4.3.3)* *LO 4.3 Determine the Euclidean distance, bandwidth and probability of error for a digital modulation scheme. (P.I.- 1.3.1)* *LO 4.4 Develop ability to independently learn the applications of MSK/ QAM. (P.I. 11.1.3).*	
05.	**Baseband detection** ***Learning Objective/s:*** *To teach the fundamentals of baseband signals, including their characteristics, representation, and how they relate to the transmitted message.* *To help learners understand the role of baseband receivers in recovering transmitted information from modulated signals.*	**06**
	Contents:	
	Probability of error and transfer function of baseband receivers, Integrate and dump receiver, Optimum Receiver, Matched filter, Correlator.	

	Self-Learning Topics: ***Properties of Matched filter***	
	Learning Outcomes : *A learner will be able to* *LO 5.1 Apply the concept of signal to noise ratio to understand the importance of its characteristics in digital communication systems. (P.I.- 1.3.1)* *LO 5.2 Apply concepts of the optimum receiver characteristics to evaluate the probability of error in the communication system. (P.I.-1.4.1)* *LO 5.3 Compare different baseband receivers. (P.I.-2.2.4)* *LO 5.4 Develop ability to independently learn the properties of Matched filter. (P.I.- 11.1.3)*	
06.	**Spread Spectrum Modulation**	**06**
	Learning Objective/s: ***To facilitate the importance of Spread Spectrum Systems in digital communication.***	
	Contents: Spread Spectrum Modulation: Need for spread spectrum modulation, pseudo noise sequence generation, direct sequence spread spectrum (DSSS). Processing gain and jamming margin, frequency–hop spread spectrum (FHSS) Application of spread spectrum: DS-CDMA.	
	Self-Learning Topics: ***Additional real time applications of spread spectrum***	
	Learning Outcomes: *A learner will be able to* *LO 6.1 Apply concepts of Spread Spectrum Modulation to obtain the threshold for processing gain. (P.I.-1.4.1)* *LO 6.2 Compare different modulation schemes with pseudo-noise sequence used in DSSS and FHSS to spread the signal across a wider bandwidth. (P.I.-2.2.4)* *LO 6.3 Develop ability to independently learn the real time applications of spread spectrum techniques. (P.I.- 11.1.3)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply concepts of electronics and communication engineering and allied disciplines to solve engineering problems.
2.2.4	Compare and contrast alternative solutions to select the best methodology.
2.4.1	Apply engineering mathematics and computations to solve mathematical models.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis
3.1.6	Determine design objectives, functional requirements and arrive at specifications
3.3.3	Identify suitable criteria for evaluation of alternate design solutions
4.3.3	Represent data (in tabular and/or graphical forms) to facilitate analysis and explanation of the data, and drawing of conclusions
11.1.3	Develop ability to learn independently through methods distinct from instructor provided materials.

Course Outcomes: A learner will be able to -

1. Apply the concepts of information theory in source coding. (*LO 1.1, 1.2, 1.3*)
2. Compare different error control systems, line codes and baseband- bandpass modulation schemes. (*LO 2.3, 3.1, 4.1, 5.3, 6.2*)
3. Solve numerical based on error detection, error correction, baseband transmission, modulation and spread spectrum schemes. (*LO 2.1, 2.2, 3.2, 3.3, 4.2, 4.3*)
4. Analyze the performance of spread spectrum and optimum baseband detection. (*LO 5.1, 5.2, 6.1*)
5. Develop self-learning ability in advanced topic related to digital communication such as equalizers, baseband- bandpass and spread spectrum modulation schemes. (*LO 3.4, 4.4, 5.4, 6.3*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ECPCC510.1	3	3	-	-	-	-	-	-	-	-	-
ECPCC510.2	-	3	-	-	-	-	-	-	-	-	-
ECPCC510.3	3	3	3	3	-	-	-	-	-	-	-
ECPCC510.4	3	-	-	-	-	-	-	-	-	-	-
ECPCC510.5	-	-	-	-	-	-	-	-	-	-	3
Average	3	3	3	3	-	-	-	-	-	-	3

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. H. Taub, D. Schlling, and G. Saha-Principles of Communication Systems, Tata Mc- Graw Hill, New Delhi, Third Edition, 2012
2. Lathi B P, and Ding Z-Modern Digital and Analog Communication Systems, Oxford University Press, Fourth Edition, 2017
3. Haykin Simon-Digital Communications, John Wiley and Sons, New Delhi, Fourth Edition, 2014.
4. John G. Proakis-Digital Communications, McGraw-Hill, Fourth Edition

Reference Books:

1. Simon Haykin, “Communication System”, John Wiley & Sons , 5th Edition,2009.
2. Taub Schilling And Saha, “Principles Of Communication Systems”, Tata Mc-Graw Hill, 3rd Edition,2007.
3. Amitabha Bhattacharya, “Digital Communication”, Mcgraw Hill, 1st Edition. 2005.

Other Resources :

1. Course: Network Analysis by Prof. Tapan Kumar Bhatttacharya, IIT Kharagpur; Weblink - https://archive.nptel.ac.in/courses/108/105/108105159/

A. IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment-Theory (20 Marks)

Suggested breakup of distribution

a) Assignments based on class notes: 10 Marks

b) Open book test: 05 Marks

c) Regularity and active participation: 05 Marks

3. Mid Semester Examination (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

B. END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20% to 30% weightage, and the syllabus covered from MSE to ESE carrying 70% to 80% weightage

Course Type	Course Code	Course Name	Credits
PEC	ECPEC5011	Electromagnetic Wave Theory	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. ECPCC301 Engineering Mathematics-III
2. ECPCC405 Engineering Mathematics-IV
3. BSC205 Engineering Physics-II

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO4: Conduct Investigations of Complex Problems
4. PO8: Individual and teamwork
5. PO9: Communication
6. PO11: Life-long learning

Course Objectives:

1. To familiarize with electromagnetics field including static and dynamic in terms of Maxwell's equations.
2. To convey Maxwell's equation to solve various electromagnetic phenomenon.
3. To develop an understanding related to electromagnetic laws and their application to solve engineering problems.
4. To convey the use of suitable computer-aided method to plot a given field problem.

Module	Details	Hrs.
	Course Introduction What is a field? What is the nature of a field? How is magnetic field produced by a current-carrying coil? How does a capacitor store energy? What is an electromagnetic wave? How does it travel? This course answers these and more questions that every electronics & telecommunication engineer should be aware of. Though electromagnetic wave theory is very well established through the works of stalwarts like Faraday, Coulomb, Gauss, Maxwell etc. it stands strong in today's world of 5G -6G communication due to the solid foundation it provides to modern communication systems. It also enables a learner to acquire imaginative thinking, analytical skills and problem-solving skills.	**01**

01.	**Co-ordinate systems and vector calculus** ***Learning Objective:*** ***1. To introduce significance of various coordinate systems with reference to electromagnetic fields.*** ***2. To help students appreciate the ideas of vector fields and various operations like gradient/curl on them.***	**07**
	Contents: Cartesian Coordinates, Circular Cylindrical Coordinates, Spherical Coordinates. Differential Length-Area-Volume, Line-Surface-Volume Integrals, Gradient of a Scalar, Divergence of a Vector and Divergence Theorem, Curl of a Vector and Stokes's Theorem, Laplacian of a Scalar, Vector fields and their classification.	
	Self-Learning Topics: Other coordinate systems	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Identify co-ordinate system and its parameters to solve a given problem. (PI 2.1.2)* *LO 1.2: Identify mathematical knowledge related to differential and integral of different parameters such as length, volume, area to evaluate their values for given boundary conditions. (PI 2.1.3)* *LO 1.3: Apply fundamentals of vector field to determine gradient/divergence and curl. (PI 1.3.1)* *LO 1.4: Apply fundamentals of vector field to classify them. (PI 1.4.1)* *LO 1.5: Develop ability to learn co-ordinate systems through Team-Pair-Solo and present effectively. (PI 1.3.1, PI 8.1.1, PI. 8.2.1, PI. 9.1.1, PI 9.2.1, PI 11.1.2, PI. 11.1.3)*	
02.	**Electrostatics** ***Learning Objective:*** ***1. To introduce concepts of force, intensity, flux density, potential and solve related problems.*** ***2. To explain how electric fields, behave in different materials.*** ***3. To facilitate understanding of Boundary condition solving and importance of continuity.***	**07**
	Contents: Coulomb's Law and Field Intensity, Electric Flux Density, Gauss's Law, Applications of Gauss's Law, Electric Potential, Electric dipole, Energy stored in electric field, Electric fields in material space- Conductors, Boundary Conditions, Poisson's and Laplace's Equations, Resistance and Capacitance. Current and current density, The continuity equation, Relaxation time, Electromotive Force.	
	Self-Learning Topics: Polarization in Dielectrics, Linear, Isotropic, and Homogeneous Dielectrics, Method of images	
	Learning Outcomes:	

	A learner will be able to *LO 2.1: Apply different laws of electromagnetics to analyse their applications. (PI 1.4.1)* *LO 2.2: Identify law of electromagnetics and apply its knowledge to determine different parameters such as force, electric field intensity, energy for a given system. (PI 2.1.3)* *LO 2.3: Apply law of electromagnetics to derive boundary conditions, continuity equation, Laplace and Poisson's equation. (PI 2.4.1)* *LO 2.4: Develop ability to learn laws of electromagnetics through Team-Pair-Solo and present effectively. (PI 1.3.1, PI 8.1.1, PI. 8.2.1, PI. 9.1.1, PI 9.2.1, PI 11.1.2, PI. 11.1.3)*	
03.	**Magneto statics** ***Learning Objective:*** ***1. To teach various laws related to static magnetic fields with their usage.*** ***2. To help learners appreciate importance of scalar and vector magnetic potential.***	**06**
	Contents: Biot-Savart's Law, Ampere's Circuit Law, Applications of Ampere's Law, Magnetic Flux Density/Intensity, Inductances, Ampere circuital law, Magnetic vector potential and magnetic scalar potential.	
	Self-Learning Topics: Magnetic Boundary Conditions, Energy in magnetic field	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply different laws of electromagnetics to analyze their applications. (PI 1.4.1)* *LO 3.2: Identify and apply appropriate magnetostatic law to solve a given problem. (PI. 2.1.2)* *LO 3.3: Compare magnetostatic laws to select appropriate one for a given input condition. (PI. 2.2.4)* *LO 3.4: Apply fundamentals of electromagnetics to understand concepts of magnetic scalar and vector potential. (PI 1.4.1)* *LO 3.5: Develop ability to learn laws of electromagnetics, concept of magnetic scalar/vector potential through Team-Pair-Solo and present effectively. (PI 1.3.1, PI 8.1.1, PI. 8.2.1, PI. 9.1.1, PI 9.2.1, PI 11.1.2, PI. 11.1.3)*	
04.	**Time-varying Fields and Maxwell's Equations** ***Learning Objectives:*** ***1. To relate laws studies in static and electrical magnetic fields as Maxwell's equations.*** ***2. To help learners appreciate the concept of displacement current and how it leads to modification of Maxwell's equation for time-varying fields.*** ***3. To make learners understand importance of Maxwell's work in establishing the concept of travelling energy.***	**08**
	Contents: Motional emf, Faraday's law of induction, Self-and mutual inductance, Displacement Current and Density, Maxwell's equations for static fields, Maxwell's equations for time-varying fields in point and integral forms, The Poynting theorem and Poynting Vector	

	Self-Learning Topics: Time harmonic fields	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply law of natural science such as Faraday law to determine induction. (PI 1.2.1)* *LO 4.2: Apply fundamentals of various laws for static and time-varying fields to understand significance of each of the Maxwell's equations. (PI 1.4.1)* *LO 4.3: Apply knowledge of electromagnetic laws and related mathematics to derive Maxwell's equations and (PI 2.4.1)* *LO 4.4: Identify mathematical and relevant knowledge to derive Poynting theorem. (PI 2.1.3)*	
05.	**Electromagnetic Wave Propagation** ***Learning Objective/s:*** ***1. To develop general wave equation from Maxwell's equations.*** ***2. To derive wave equation for different mediums.*** ***3. To explain concept of polarization.*** ***4. To relate what happens when the EM wave undergoes reflection.***	**08**
	Contents: General wave equation, Wave Propagation in various mediums—lossy dielectric, free space, lossless dielectric and good conductors, Polarization and its types, Reflection of a Plane Wave at Normal Incidence, Reflection of a Plane Wave at Oblique Incidence	
	Self-Learning Topics: Importance of wave polarization in mobile transmission.	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Identify and apply appropriate Maxwell's equation to derive general wave equation (PI. 2.1.3)* *LO 5.2: Apply Maxwell's equations and related mathematics to analyze wave propagation in various mediums.(PI 2.4.1)* *LO 5.3: Apply fundamentals of polarization to determine type of polarization from the wave equation.(PI 1.3.1)* *LO 5.4: Apply fundamentals of EM wave propagation to understand concept of reflection of a plane wave at normal incidence and oblique incidence. (PI 1.4.1)*	
06.	**Introduction to computational electromagnetics** ***Learning Objective/s:*** ***1. To help learners understand how modelling of electromagnetic fields is done through various computer aided methods.*** ***2. To develop learner's understanding about applications of these methods to some of the studied theories***	**07**
	Contents: Finite difference method-Iteration method, Band matrix method, Finite element method, Method of moments	

	Application-Microstrip lines, Solution of Laplace/Poisson and Helmotz Wave equations using Finite Difference Method	
	Self-Learning Topics: Field plotting	
	Learning Outcomes: *A learner will be able to* *LO 6.1 Define a problem, its scope and importance for purposes of investigation. (PI 4.1.1)* *LO 6.2 Apply suitable computer-aided method to determine solution of given problem and to plot field and potential lines. (PI 4.1.3)* *LO 6.3: Identify type of method and apply it's knowledge to determine solution of wave equations. (PI 2.1.3)* *LO 6.4: Compare different computer aided methods to select the appropriate one for a given input condition. (PI 2.2.4)* *LO 6.5: Apply knowledge of computational electromagnetics to analyze different applications. (PI 1.4.1)* *LO 6.6: Develop ability to learn computer aided methods independently through software simulation assignment and present effectively. (PI 1.3.1, PI 8.1.1, PI. 8.2.1, PI. 9.1.1, PI 9.2.1, PI 11.1.2, PI. 11.1.3)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.2.1	Apply laws of natural science to an engineering problem.
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply concepts of electronics and communication engineering and allied disciplines to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem.
2.2.4	Compare and contrast alternative solutions to select the appropriate methodology.
2.4.1	Apply engineering mathematics and computations to solve mathematical models.
4.1.1	Define a problem, its scope, and importance for purposes of investigation
4.1.3	Apply appropriate instrumentation and/or software tools to make measurements of physical quantities.
8.1.1	Recognize a variety of working and learning preferences; appreciate the value of diversity on a team
8.2.1	Demonstrate effective communication, problem-solving, conflict resolution and leadership skills
9.1.1	Read, understand and interpret technical and/or non-technical information.
9.2.1	Listen to and comprehend information, instructions, and viewpoints of others.
11.1.2	Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to close this gap
11.1.3	Develop ability to learn independently through methods distinct from instructor provided materials.

Course Outcomes: A learner will be able to -

1. Choose appropriate vector operator among gradient, curl and divergence to solve given field problem for particular co-ordinate system. *(LO 1.1 to LO 1.5)*
2. Apply static fields laws to describe and determine parameters for different charge configurations. *(LO 2.1 to LO 2.4)*
3. Select appropriate magnetostatic laws to determine field parameters. *(LO 3.1 to LO 3.5)*
4. Derive Maxwell's equations for static and time varying conditions. *(LO 4.1 to LO 4.4)*
5. Apply Maxwell's equation to solve various electromagnetic phenomenon such as electromagnetic wave propagation in different medium, power in EM wave. *(LO 5.1 to LO 5.4)*
6. Model a given field problem with a suitable computer-aided method and analyze the solution. *(LO 6.1 to LO 6.6)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECPE5011.1	3	3						3	3		3	
ECPE5011.2	3	3						3	3		3	
ECPE5011.3	3	3						3	3		3	
ECPE5011.4	3	3									3	
ECPE5011.5	3	3									3	
ECPE5011.6	3	3		3				3	3		3	
Average	3	3		3				3	3		3	

Text Books :

1. Electromagnetic Waves and Radiating Systems- Jordan and Balmain, PHI, 2nd edition
2. Principles of Electromagnetics Engineering- Matthew N. O.Sadiku , S.V.Kulkarni, Oxford university press, 6th edition

Reference Books :

1. Engineering Electromagnetics, William H Hayt and John A Buck, Tata McGraw-Hill Publishing Company Limited, 7th edition
2. Electromagnetism-Problems with solutions, Ashutosh Pranik, PHI learning Private limited, 2nd edition
3. Engineering Electromagnetics, Umran S. Inan, Aziz S. Inan, Pearson publication
4. Field Theory, K.A.Ganghdhar, P M Ramanathan, Khanna Publishers

Other Resources :

1. NPTEL- Electromagnetic Theory by Prof. Pradeep Kumar, IIT Kanpur
   https://www.youtube.com/playlist?list=PLFW6lRTa1g80n91bZDKR8izUxfa_TKk3J
2. NPTEL-Transmission Lines and EM Waves by Prof. R.K. Shevgaonkar**,** IIT Bombay
   https://www.youtube.com/playlist?list=PL0CD49F1FAD4E6FAA

IN-SEMESTER ASSESSMENT (75 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

1. Class test: 5 marks
2. Software simulation assignment: 5 marks
3. Team-Pair-Solo: 5 marks
4. Regularity and active participation: 5 marks

4. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
PE	ECPEC5012	Computer Communication Networks	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. Principles of communication
2. Digital communication

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO5 : Modern tool usage
4. PO9 : Written communication
5. PO11: Life-long learning

Course Objectives:

1. To introduce networking architecture and protocols.
2. To educate students OSI and TCP/IP, the layer-wise functions, services, data formats, protocols, hardware devices and addresses in the OSI and TCP/IP architecture.
3. To build an understanding of various protocols so as to make students comprehend each of them.
4. To apply different addressing and routing schemes to be able to solve numerical and comparative analysis.
5. To make students apply knowledge and analyse various processes involved in networking.

Module	Details	Hrs.
	Course Introduction The "Computer Communication Networks" course is crucial for students in Electronics and Telecommunication engineering, in understanding the types of Networks related to Telecommunication. This course provides the basic terms and background insights on computer networks and related protocols essential in both academic and industry applications.	**01**
01.	**Introduction to Network Architectures and layered services** ***Learning Objective:*** *1. To educate students on the concept of formation of networks with computer devices and their identification* *2. To deliver knowledge on the OSI layered models and types of addressing used with computer networks.* *3. To introduce students about the hardware devices available at different layers and their usage in computer network.*	**06-07**

	4. To teach students the use of IP utility commands in order to troubleshoot networks.	
	Contents: Applications of computer networks. Network types: LAN, MAN, and WAN, Network topologies. OSI reference model 7 layer, 4 layer TCP/IP model, protocols at each layer, addressing used with computer networks: physical, logical, port addressing, socket addressing. Layer wise network hardware devices (NIC, Repeaters, Hubs, Bridges, Switches, Routers, Gateway and their comparison) Troubleshooting of network using IP utility commands.	
	Self-Learning Topics: *Review on CAN, PAN and WLAN networks*	
	Learning Outcomes: *A learner will be able to* *LO 1.1* *Apply knowledge of various network types and topologies, OSI reference model and TCP/IP model to arrive at conclusions. (PI: 1.4.1)* *LO 1.2* *Identify the types of network devices, addresses required and ports used based on the given scenarios. (PI: 2.1.3)* *LO 1.3* *Compare various network devices, their use and addressing techniques for the computer networks. (PI: 2.4.4)* *LO 1.4* *Analyse information related to a network and troubleshoot using IP utility commands . (PI: 5.2.2)*	
02.	**Physical Layer and broadband standards** ***Learning Objective:*** *1. To impart knowledge on various Broadband standards used at data link layer.* *2. To provide introduction to transmission media and impairments.*	**05-06**
	Contents: Guided transmission media: comparison among coaxial, optical fiber and twisted pair cables. Unguided transmission media and wireless standards Transmission impairments: attenuation, dispersion and noise Broadband standards: Cable modem, DSL and Fiber to the home.	
	Self-Learning Topics: *Advantages and disadvantages of various wired and wireless media*	
	Learning Outcomes: *A learner will be able to* *LO 2.1* *Identify the types of media or broadband standard applicable for a given problem statement or objective of computer networking (PI: 2.1.3)* *LO 2.2* *Compare various transmission media and utility in computer networks. (PI: 2.4.4)*	
03.	**Data Link Layer and media access protocols** ***Learning Objective:*** *1. Teach students to illustrate the error and flow control in data link layer.*	**06-07**

	2. *To introduce students ARQ techniques and medium access techniques in computer networks.* 3. *To make students compare the type of medium access protocols such as ALOHA and CSMA*	
	Contents: Data link services: Framing, Flow control, Error control at data link layer ARQ methods, Transmission efficiency in ARQ methods, Medium Access Control Protocols: ALOHA, Slotted ALOHA, CSMA/CA and CSMA/CD High Level Data Link Control (HDLC): bit stuffing and de-stuffing concept.	
	Self-Learning Topics: *HDLC Frame format and configurations, Piggybacking*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply the knowledge on data link layer services and data link layer protocols to illustrate the concept of piggybacking and HDLC. (PI:1.4.1) (PI:9.1.2) (PI:11.1.3)* *LO 3.2: Determine transmission efficiency for MAC protocols. (PI:2.4.1)* *LO 3.3: Compare the type of medium access protocols such as ALOHA, CSMA and ARQ techniques. (PI: 2.2.4)*	
04.	**Network Layer : protocols and routing algorithms**	**08-09**
	Learning Objectives: 1. *To make students apply the concept of subnetting according to an organization's need and solve subnetting problems.* 2. *To make students understand how to apply routing algorithms to construct routing tables* 3. *To make students differentiate between IP versions, addressing and hardware at various layers.* 4. *To extract the understanding through illustrative examples how computer communication network helps in circuit switching and packet switching for the applications customers seek*	
	Contents: Circuit switching and packet switching principles. Internet Protocol: Principles of Internetworking, requirements, IPv4 packet header, IPv4 addressing, classful and classless addressing concept, subnetting for Internet service providers and related numericals. Introduction to ARP, RARP and ICMP **** wireshark packet capture software demonstration in class IPv6 (IPv6 Datagram format, comparison with IPv4, and transition from IPv4 to IPv6) Routing in Packet Switching Networks: Routing strategies, Routing algorithms: Link state Routing, Distance vector Routing and Path vector routing, Routing protocols: RIP, OSPF, BGP. *** cisco packet tracer demonstration during class Introduction to MPLS (Multi-protocol label switching)	
	Self-Learning Topics:	

	Super-netting concept, EIGRP protocol	
	Learning Outcomes: *A learner will be able to* *LO 4.1 : Classify the addressing, IP versions and routing algorithms with respect to the utilities and features. (PI: 2.2.4)* *LO 4.2: Apply knowledge of the different routing protocols and illustrate the preparation of routing tables.(1.4.1)(11.3.1)* *LO 4.3: Determine the subnets as per the requirements of an organization and ISP. (PI:2.1.3)* *LO 4.4: Analyse the IP header and interpret the packet information from header Fields using Open-source software tools such as Wireshark for protocol observation and CISCO packet tracer for simulation of networks (PI: 5.2.2) (PI:2.4.1)*	
05.	**Transport layer** ***Learning Objective/s:*** 1. *To develop understanding of connection oriented and connection less services with computer networks.* 2. *To provide advantages and disadvantages between protocols used at the same layer of TCP/IP protocol suite.* 3. *To make students perform the checksum calculations and header analysis for TCP and UDP.*	**07-08**
	Contents: Connectionless and Connection–oriented services at transport layer,User datagram Protocol (UDP) header, well known UDP ports, advantages and limitations of UDP service. Transmission Control Protocol (TCP): TCP Services, TCP Segment fields, checksum calculation in TCP, TCP three-way handshake, State transition diagram in TCP, advantages of TCP, Retransmission of TCP segments, Flow control, error control and congestion control in TCP, well known TCP ports, limitations with TCP.	
	Self-Learning Topics: *RTO, Keepalive and Persistence timers in TCP*	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Provide insights on the TCP handshake, flow control, error control and TCP services, state transition diagram and timers. (1.4.1) (9.1.2) (11.3.1)* *LO 5.2: Perform header analysis for TCP and UDP to arrive at conclusions. (1.3.1)((PI :2.4.1)*	
06.	**Application Layer** ***Learning Objective/s:*** 1. *To introduce students port numbers associated with different applications*	**06-07**

	2. To make students aware of the security issues with computer networks and introduce possible solutions	
	Contents: Introduction to Application layer Protocols and port numbers associated with popular protocols, HTTP, SMTP , FTP, DNS and DHCP Secured protocols : HTTPs, SSL and IPSec	
	Self-Learning Topics: *Remote login using TELNET and SSH*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Apply the knowledge on the concepts of DNS, FTP, SMTP and DHCP to the given scenario. (2.1.3)* *LO 6.2: Enlist the application layer related protocols specifying their utilities. (1.4.1)* *LO 6.3 Justify with reasoning the use of various remote login procedures, domain name resolution and the host configuration. (1.4.1)(9.1.2)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply concepts of electronics and communication engineering and allied disciplines to solve engineering problems.
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem.
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions.
2.2.4	Compare and contrast alternative solutions to select the best methodology.
2.4.1	Apply engineering mathematics and computations to solve mathematical models and analyse results
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis
5.2.2	Demonstrate proficiency in using discipline-specific tools.
9.1.2	Create clear, well-constructed, and well-supported written engineering documents and/or presentation.
11.1.3	Develop ability to learn independently through methods distinct from instructor provided materials
11.3.1	Source and comprehend technical literature and other credible sources of information

Course Outcomes: A learner will be able to –

1. Identify the protocol usage from the layers in TCP/IP model and requirement of network hardware devices, transmission media and medium access methods.*(LO 1.1, LO 5.1, LO 6.2)*
2. Perform analysis on IPv4 header, transport layer headers and determine the subnetting and routing table entries. (*LO 3.2, LO 4.2, LO 4.3, LO 4.5)*
3. Distinguish between the various network architectures, protocol suites, transport and application layer protocols, routing algorithms, IP versions and medium access control methods. (*LO 1.2, LO 1.3, LO 2.1, LO 2.2, LO 3.3, LO 4.1)*
4. Analyze the layers in TCP/IP model and troubleshoot using various opensource software platforms. *(LO 1.4, LO 4.4, LO 5.2)*
5. Justify by appropriate reasoning the need of layer-wise protocols, secured transmission and the use of wired or wireless media for computer networks (*LO 3.1, LO 6.1, LO 6.3)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ECPEC5012.1	3	3							2		3
ECPEC5012.2	3	3									
ECPEC5012.3	3	3									
ECPEC5012.4	3	3			2				2		
ECPEC5012.5	3	3							2		3
Average	3	3			2				2		3

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. Data Communications and Networking – Behrouz A. Forouzan, Fifth Edition TMH,2013
2. Computer Networks -- Andrew S Tanenbaum, 5th Edition, Pearson Education, 2013
3. J. F. Kurose and K. W. Ross," Computer Networking: A Top-Down Approach", Addison Wesley. ," Computer Networking: A Top-Down Approach", Addison Wesley, 5th Edition, 2010.

Reference Books :

1. Alberto Leon Garcia, "Communication Networks", McGraw Hill Education, Second, . Edition, Fourth Edition, 2008.
2. An Engineering Approach to Computer Networks-S.Keshav, 2nd Edition, Pearson Education, 2015.
3. Data and Computer Communications, William Stallings, 10th Edition, Pearson Education, 2014.

4. Understanding communications and Networks, 3rd Edition, W.A.Shay, Cengage Learning

Other Resources :

1. By Prof. Soumya Kanti Ghosh, Prof. Sandip Chakraborty | IIT Kharagpur
2. Computer Networks and Internet Protocol - Course (nptel.ac.in)

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

a) In-class simulations and Assignments: 10 Marks
b) Quizzes (04) : 05 Marks
c)Regularity and active participation: 05 Marks

3. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
PE	ECPEC5013	Digital VLSI	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. BSC102 Engineering Physics-I
2. ECPCC303 Electronics Devices and Circuits
3. ECPCC304 Digital Circuit Design

Program Outcome addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of Solution
4. PO5: Modern Tool Usage
5. PO8: Individual and Team work
6. P09: Communication
7. PO11: Lifelong Learning

Course Objectives:

1. To learn the basic concepts of MOSFETs, layout, fabrication. and solve the problems to analyse the MOSFETs.
2. To analyse performance metrics of CMOS Inverter, NAND, NOR gate.
3. To design combinational and sequential circuits using different design styles.
4. To analyse the working of RAM and ROM array.
5. To provide exposure on static timing analysis and CMOS testing.

Module	Details	Hrs.
	Course Introduction The field of CMOS Integrated circuits is broadly divided into digital and analog CMOS circuits. However, the boundary between classical digital and analog CMOS design is becoming very less, especially with the challenges presented by nanometer scale fabrication technologies, low operating voltages and frequencies. Here we start with the fabrication and end with the testing of CMOS circuits under different conditions.	**01**
01.	**VLSI Technology- Circuit, Layout and Fabrication** ***Learning Objective:*** ***1. Analyze and interpret the basics of MOSCAP and MOS Transistor.*** ***2. To analyze and design the concepts of Stick Diagram, Layout and fabrication processes.***	**10-13**
	Contents: • Overview of VLSI Design Flow, Metal Oxide Semiconductor Structure, MOS under External Bias, Operation of MOS Transistor. Threshold voltage equation and energy band diagram of MOSFET, controlling of threshold voltage. MOSFET current-voltage characteristics, MOSFET	

	Capacitance, Small-Geometry Effects-. Scaling, short channel effects • Layout: Stick diagrams, Design Rule Background, Micron/Lambda Design Rule. • Fabrication: CZ Process, Process(Oxidation, Epitaxial, Lithography, Diffusion, Ion Implantation, Metallization) flow of NMOS and CMOS. ***Self-Learning Topics:****ITRS Website, Comparison of depletion and enhancement type of MOSFETs* ***Learning Outcomes:*** *A learner will be able to* *LO 1.1: Apply fundamental engineering concepts to realize the operation, characteristics and band diagram of MOSFET. (P.I.-1.3.1)* *LO 1.2: Apply concepts of semiconductor physics and material science to comprehend Threshold Voltage, MOS Capacitance, Scaling and Short Channel Effects. (P.I.-1.4.1)* *LO 1.3: Identify the aspect ratio and lambda rules to construct layout of combinational logic circuits for a given boolean expression. (P.I.-2.1.3)* *LO 1.4: Identify existing methods for analyzing different process flow of fabrication for NMOS, PMOS and CMOS. (P.I.-2.2.3)* *LO 1.5: Develop ability to learn custom layouts through Think-Pair-Solo and present effectively. (PI 8.1.1, PI. 8.2.1, PI. 9.1.1, PI 9.2.1, PI 11.1.2, PI. 11.1.3)*	
02.	**Combinational CMOS Logic Circuits** ***Learning Objective:*** 1. *To analyze basics of CMOS Inverter, NAND and NOR gate for different performance metrics.* 2. *To design CMOS Inverter, NAND, NOR and complex logic circuits.* **Contents:** • CMOS Inverter Operation, Characteristics, Static and Dynamic Analysis (Noise margin, Propagation delay and Power dissipation), Design of CMOS Inverter and Layout of CMOS Inverter, CMOS Latch-up. • Realization of CMOS NAND gate, NOR gate, Complex CMOS Logic Circuits Layout of NAND ,NOR and Complex CMOS Circuits ***Self-Learning Topics:*** *Logical Effort* ***Learning Outcomes:*** *A learner will be able to* *LO 2.1: Apply fundamental engineering concepts to identify the operation of CMOS Inverter, NAND and NOR gate (P.I.-1.3.1)* *LO 2.2: Identify basic concepts of CMOS Inverter and analyze all the basic performance metrics of VLSI design (Noise margin, Propagation delay, Power dissipation and Area.in static and dynamic state (P.I.- 2.1.3)* *LO 2.3: Identify the relevant data from the resources to design NAND and NOR gate in terms of CMOS Inverter to arrive to an optimal design. (P.I-3.3.3,)* *LO 2.4: Develop ability to learn to solve the critical voltages of CMOS Inverter and design it through Think-Pair-Solo and present effectively. (P.I-1.4.1, P.I-2.3.1, P.I-3.1.6, PI 8.1.1, PI. 8.2.1, PI. 9.1.1, PI 9.2.1, PI 11.1.2, PI. 11.1.3)*	**6-8**
03.	**MOS Design Logic Styles** ***Learning Objective:*** 1. ***To design, implement and verify combinational and sequential logic circuits using various MOS design styles.***	**9-11**

	2. ***To introduce VLSI performance metrics and various tradeoffs.***	
	Contents: • Static CMOS, Pass Transistor Logic, Transmission Gate, Pseudo NMOS, Dynamic Logic, Domino Logic, NORA, Zipper, C^2MOS • Clocked CMOS SR Latch, CMOS JK Latch, MS –JK Flip Flop, Edge triggered D-Flip Flop and realization using design styles • Realization of Shift Register, MUX, Decoder using above design styles ,1-bit full adder	
	Self-Learning Topics: Corner Stitching analysis.	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply fundamental engineering concepts to solve problems of Combinational design styles. (P.I-1.3.1).* *LO 3.2: Apply concepts of electronics engineering and digital systems to solve engineering problems on sequential design styles (P.I-1.4.1).* *LO 3.3: Analyze the basic concepts of different design styles for combinational and sequential circuits leading to conclusions in terms of merits and limitations. (P.I-2.4.4)* *LO3.4: Identify the relevant data from the resources (design styles), analyze and design the circuit for a given expression. (P.I.-3.3.3)* *LO 3,5: Identify suitable criteria for evaluation of alternate design solutions using different styles for applications of digital design such as full adder ,Decoder etc. and give the limitations for the same based on performance metrics.(P.I-3.2.3,P.I-2.4.3).*	
04.	**Semiconductor Memories** ***Learning Objectives:*** 1. *To learn the working of NAND based ROM array, NOR based ROM array* 2. *To provide analysis and design using simulator/editors on SRAM and DRAM*	**4-6**
	Contents: • ROM array-NAND and NOR based ROM array, 6T-SRAM (operation, design strategy, leakage currents, sense amplifier), layout of SRAM, Peripheral Circuits • Operation of 1T and 3T DRAM Cell, NAND and NOR flash memory	
	Self-Learning Topics: *Fowler Nordheim Tunneling*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply core principles of engineering to classify semiconductor memories. (P.I-1.4.1)* *LO 4.2: Apply fundamental engineering concepts to solve the problems of volatile memories. (P.I-1.3.1)* *LO 4,3: Identify and design NAND/NOR based ROM array for a given matrix using open-source tool. (P.I-3.1.6, P.I- 5.1.2)* *LO 4.4: Identify the mathematical approach that applies to NAND and NOR flash memory. (P.I-2.1.3)* *LO 4.5: Extract the understanding objectives and limitations of 6T SRAM / 3T DRAM (P.I-2.4.4)*	

	LO 4.6: Design 6T SRAM / 3T DRAM using layout editor for the given specification. (P.I-3.3.3,P.I-5.3.3)	
05.	**Static Timing Analysis** ***Learning Objective/s:*** *1. To introduce the various STA checks for timing closure and Step-by-step structured timing analysis.* **Contents:** • Introduction to basic characteristics of setup and hold analysis, data check and latch timing, Slew, load, clock checks and timing graph • Clock to q delay, library setup, Hold time and jitter, Textual Timing reports and hold analysis, On Chip variation, OCV timing and pessimism removal • Introduction to open timer, netlist definition and constraint creation commands. ***Self-Learning Topics:*** ***Learning Outcomes :*** *A learner will be able to* *LO 5.1: Apply fundamental engineering concepts to comprehend the concept of basic characteristics of setup and hold analysis. (P.I.-1.3.1).* *LO 5.2: Apply fundamentals of open timer to solve the various STA checks. (PI-1.4.1)* *LO 5.3: Analyze concepts of clk-qdelay to create eye diagram in jitter analysis accounting to setup and hold timing analysis with conclusions in terms of limitations. (P.I-2.4.4)* *LO 5.4: Identify the basics of On Chip variation, OCV timing and pessimism removal that applies to a given problem. (P.I-2.1.3).*	**4-6**
06.	**CMOS Testing** ***Learning Objective/s:*** *1.To learn about the testing processes of CMOS circuits under different conditions..* **Contents:** CMOS Testing, Need for Testing, Test Principles, Design Strategies for Test, Chip Level and Board Level Test Techniques. ***Self-Learning Topics:*** ***Learning Outcomes:*** *A learner will be able to* *LO 6.1: Apply and identify the importance of testing in the VLSI design and manufacturing lifecycle. (P.I-1.4.1)* *LO 6.2: Apply fundamental test principles to understand key concepts like controllability and observability in digital circuit testing. (P.I.-1.3.1)* *LO 6.3: Identify test challenges in modern high-density integrated circuits.for a testable design system. (P.I.-2.1.3)* *LO 6.4: Compare techniques used in wafer-level, die-level, and package-level testing. (P.I.-2.2.4)*	**3-5**

	Course Conclusion	**01**
	Total	**45**

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ECPEC5013.1	3	3						3	3		3
ECPEC5013.2	3	3	3					3	3		3
ECPEC5013.3	3	3	3		3						
ECPEC5013.4	3	3									
ECPEC5013.5	3	3									
Average	3	3	3	3	3			3	3		3

Performance Indicators:

P.I. No.	P.I. Statement
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply concepts of electronics and communication engineering and allied disciplines to solve engineering problems.
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem.
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions.
2.2.4	Compare and contrast alternative solutions to select the best methodology.
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
2.4.3	Identify sources of error in the solution process, and limitations of the solution.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis
3.1.6	Determine design objectives, functional requirements and arrive at specifications Curriculum Structure and Syllabi (R-2024) – B. Tech. in Computer Engineering
3.2.3	Identify suitable criteria for evaluation of alternate design solutions
3.3.3	Identify relevant data from the given resources and arrive at an optimal design solution for particular specifications.
5.1.2	Use/adapt/modify/create tools and techniques to solve engineering problems
5.3.3	Recognize sources of error in measurements, modelling or simulations and verify credibility of results.
8.1.1	Recognize a variety of working and learning preferences; appreciate the value of diversity on a team
8.2.1	Demonstrate effective communication, problem-solving, conflict resolution and leadership skills
9.1.1	Read, understand and interpret technical and/or non-technical information.
9.2.1	Demonstrate effective communication, problem-solving, conflict resolution and leadership skills
11.1.2	Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to close this gap

11.1.3 Develop ability to learn independently through methods distinct from instructor provided materials.

Course Outcomes:

1. To comphrend qualitative knowledge about MOSFET operation, characteristics, layout and fabrication processes of integrated circuit using MOS transistors *(LO 1.1, LO 1.2, LO1.3, LO1.4, LO 1.5)*
2. Compute, analyse and design the performance parameters of basic building blocks like CMOS Inverter, NAND and NOR with layouts. *(LO 2.1, LO 2.2, LO2.3, LO 2.4*)
3. Analyse and design the working of various design style, CMOS combinational, sequential and semiconductor memories used in VLSI Design. *(LO 3.1, LO 3.2, LO3.3, LO3.4, LO 4.1, LO 4.2, LO 4.3,LO4.4,LO4.5,LO4.6*)
4. Apply the concepts of STA to set constraints, analyse reports generated by static timing analysis tools. *(LO 5.1, LO 5.2, LO 5.3, LO 5.4*)
5. Comprehend and analyse various CMOS testing tools, processes under different fault models, test methodologies, and design-for-testability strategies *(LO 6.1, LO 6.2, LO 6.3, LO 6.4*)

Text Books :

1. Sung-Mo Kang and Yusuf Leblebici, "CMOS Digital Integrated Circuits Analysis and Design", Tata McGraw Hill, 3rd Edition, 2012
2. Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic, "Digital Integrated Circuits: A Design Perspective", Pearson Education, 2nd Edition.
3. CMOS VLSI Design-A Circuits and Systems Perspective, Neil H.E Weste, David Harris, Ayan Banerjee, 3 rd Edn, Pearson, 2009

Reference Books :

1. R. Jacob Baker, "CMOS Circuit Design, Layout and Simulation", Wiley, 2nd Edition, 2013
2. John P. Uyemura, "Introduction to VLSI Circuits and Systems", Wiley, Student Edition, 2013.
3. Neil H. E. Weste, David Harris and Ayan Banerjee, "CMOS VLSI Design: A Circuits and Systems Perspective", Pearson Education, 3rd Edition.
4. Introduction to VLSI Design-Mead & Convey,BS Publications,2010.

Other Resources :

1. NPTEL Course: CMOS Digital VLSI Design y Dr. Sudeb Dasgupta, IIT Roorkee: -Web link- CMOS Digital VLSI Design - Course
2. NPTEL Course: VLSI Design Verification and Test, By Dr.Santosh Biswas, Prof. Jatindra Deka, IIT Guwahati. Web link- https://nptel.ac.in/courses/106103016

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

1. *Numerical Assignment/s (min 20 problems)/Simulations – 05 Marks*
2. *Class test based on above numerical assignment – 05 Marks*
3. *Activity based study-Think pair solo and preparing report: 05 Marks*
4. *Regularity and active participation:05 Marks*

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination(MSE) carrying 30% weightage, and the syllabus covered from MSE to ESE carrying 70% weightage.

Course Type	Course Code	Course Name	Credits
PCC	ECPEC5014	ROBOTICS	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. BSC101- Engineering Mathematics-I
2. ESC101- Engineering Mechanics
3. ECPCC405- Engineering Mathematics-IV
4. ECSBL402- Simulation Lab

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of Solutions
4. PO6: The engineer and The World
5. PO8: Individual and teamwork
6. PO9: Communication
7. PO11: Life-long learning

Course Objectives:

1. To introduce the functional elements of Robotics
2. To impart knowledge on the direct and inverse kinematics.
3. To exhibit the manipulator differential motion and control
4. To educate on various path planning techniques
5. To familiarize the dynamics and control of manipulators
6. To acquaint about the localization, planning and navigation

Module	Details	Hrs.
	Course Introduction Robotics course provides the fundamental information and real-world skills needed to plan, design, program, and operate robotic systems. Robotics is an interdisciplinary field that builds devices that can do tasks either autonomously or with human help by integrating principles from computer science, mechanical engineering, electrical engineering, and artificial intelligence.	**01**

01.	**Introduction to Robotics** ***Learning Objective:*** ***To facilitate understanding of laws of robotics and select the robot for desired application.***	**03**
	Contents: Introduction to robotics- History, growth; Robot applications- Manufacturing industry, Defence, rehabilitation, medical, marine, autonomous vehicle, Laws of Robotics.	
	Self-Learning Topics: ***Overview of robotics and its evolution. Hard and soft automation in robotics.***	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply fundamental concepts of coordinate transformations for a desired application to determine their position and orientation. (P.I.- 1.3.1)* *LO 1.2: Apply concepts of hard and soft automation that influence the performance of a robotic arm. (P.I.- 1.4.1)* *LO 1.3: Determine design objectives of various robots, their functional requirements and arrive at specifications related to accuracy, reach, stroke and load handling capacity (P.I.- 3.1.6)* *LO 1.4: Identify relevant data from the given robot specifications and arrive at a best fitting design solution (P.I.- 3.3.3)* *LO 1.5: Describe and evaluate the Laws of Robotic principles for sustainable development based on application for preserving the safety requirement. (P.I.- 6.4.1)* *LO 1.6: Apply principles of preventive engineering and sustainable development to a robot application based on the Laws of Robotic. (P.I.- 6.4.2)*	
02.	**Robot Kinematics** ***Learning Objective:*** • *To familiarize the robotic motion using mathematical representation with desired constraints.* • *To impart and interpret the robot kinematics.*	**10**
	Contents: Mathematical representation of Robots, Robot mechanisms; Kinematics- coordinate and homogeneous transformations, Denavit Hartenberg (DH) parameters, Forward kinematics and Inverse Kinematics (upto 5-axis robotic arm). Motion constraints: Jacobians, Trajectory Planning, unicycle, differential drive and omnidirectional.	
	Self-Learning Topics: ***Mathematical problems based on homogeneous coordinate transformations.***	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply fundamental concepts of mathematical transformations to solve problems based on yaw- pitch- roll mechanism (P.I.- 1.3.1)* *LO 2.2: Apply concepts of trajectory planning to solve the motion constraint problem. (P.I.-1.4.1)*	

	LO 2.3: Identify the kinematic parameters, variables in link and joint structure of a robotic arm to solve problems based on transformations. (P.I.- 2.1.2) *LO 2.4: Identify sources of motion constraints in a robot and state the limitations to overcome the constraints (P.I.- 2.4.3)* *LO 2.5: Present results as a team, with smooth integration of contributions from all individual efforts in case study implementation of a robot application. (P.I.- 8.3.1)* *LO 2.6: Create clear constructed, and well-supported documents and presentation for the existing robotic prototype. (P.I.- 9.1.2)*	
03.	**Path Planning and AI in Robotics** ***Learning Objective:*** • *To educate path planning using algebraic principles.* • *To introduce the robotic position in work space envelope using position and orientation technique.* • *To develop learner's knowledge to apply the algebraic technique as well as AI algorithm to analyze the robotic path.* **Contents:** Path Planning: Joint space technique, Use of p-degree polynomial, Cubic polynomial, Cartesian space technique, Parametric descriptions, Straight line and circular paths, Position and orientation planning. Voronoi and hybrid approach. AI Algorithms: Probabilistic robotics, Breadth and Depth First Search algorithms. ***Self-Learning Topics:*** ***Bug based path planning algorithms.*** ***Learning Outcomes:*** *A learner will be able to* *LO 3.1: Apply fundamental concepts of position and orientation to locate the destined position in a workspace environment. (P.I.-1.3.1)* *LO 3.2: Apply the concepts of path planning algorithm to determine the characteristics related to navigation. (P.I.-1.4.1)* *LO 3.3: Identify the need for appropriate algorithm for implementing path planning mechanism (P.I.- 3.1.1)* *LO 3.4: Identify suitable AI algorithm for a desired application with multiple design solutions (P.I.- 3.2.2)* *LO 3.5: Present results as a team, with smooth integration of contributions from all individual efforts in case study implementation/ designing a robot application with appropriate path planning principle. (P.I.- 8.3.1)* *LO 3.6: Comprehend the Bug based path planning algorithms and analyze technical information for feasibility, viability, sustainability, etc. (P.I.- 11.3.2)*	**08**
04.	**Actuators** ***Learning Objectives:*** *To educate about the actuator and feedback control system used in designing robotic motion.* **Contents:**	**08**

	Actuators (electrical)- DC motors, BLDC servo motors, Sensors, sensor integration, Control – PWM, joint motion control, feedback control, Computed torque control.	
	Self-Learning Topics: ***Fundamentals of control theory and feedback systems, basic control strategies such as PID (Proportional-Integral-Derivative) control to regulate robot motion.***	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply fundamental concepts of feedback control mechanism to design robotic motion in a workspace environment. (P.I.-1.3.1)* *LO 4.2: Apply the concepts of actuators and sensors to determine the robot parameters in a particular workspace envelope. (P.I.-1.4.1)* *LO 4.3: Breakdown and analyze the complex feedback control mechanism in robotic motion control and analyse by proper assumptions. (P.I.- 2.2.1)* *LO 4.4: Compare and contrast different feedback control mechanisms to select the best method. (P.I.- 2.2.4)* *LO 4.5: Comprehend the fundamentals of control theory and feedback systems to regulate robot motion and analyze technical information for feasibility, viability, sustainability, etc. (P.I.- 11.3.2)*	
05.	**Service Robotics** ***Learning Objective/s:*** ***To instil knowledge of Simultaneous Localization and Mapping (SLAM) algorithms for an application-based robot.***	**08**
	Contents: Need for service robots. Localization: Challenges, Map Representation- Probabilistic Map based Localization Monte Carlo localization, Algorithms for simultaneous localization and mapping (SLAM). Planning and navigation: Path planning overview, Cell decomposition path planning, Potential field path planning-Obstacle avoidance, Landmark based navigation-Globally unique localization, Positioning beacon systems- Route based localization, fault detection/tolerance systems; multiple coordinated vehicles; and networked vehicles.	
	Self-Learning Topics: ***Obstacle avoidance techniques to help robots navigate in dynamic environments.***	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Apply fundamental concepts of Cell decomposition mechanism to design path planning algorithms. (P.I.-1.3.1)* *LO 5.2: Apply the concept of localization to determine the pick and place location. (P.I.-1.4.1)* *LO5.3: Identify different localization algorithms with high fault detection/tolerance capability and its need in navigating the robot with multiple design solutions. (P.I.- 3.2.2)* *LO 5.4: Apply principles of preventive engineering and sustainable development of a service robot based on SLAM algorithms (P.I.- 6.4.2)*	

06.	**Marine Robotics** ***Learning Objective/s:*** ***To explain the role of robotic systems in the marine environment.***	**06**
	Contents: Introduction to marine robotics and robotic configurations; autonomous underwater gliders (AUGs), autonomous underwater vehicles (AUVs), and remotely operated underwater vehicles. • Applications (optional) - collision avoidance, line following, occupancy grid methods. • Basics of missile guidance - Introduction to missiles, missile guidance laws (pursuit, line-of-sight, proportional navigation), capturability analysis, for maneuvering and non-maneuvering targets. • Applications of guidance strategies to cooperative control (optional)- multi-vehicle path planning, collision avoidance, docking problems.	
	Self-Learning Topics: *Case studies from India, Republic of Korea, Japan and USA.*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Apply fundamental concepts of control theory to design marine robotic systems for stable movement and navigation. (P.I.-1.3.1)* *LO 6.2: Apply engineering concepts to determine factors like buoyancy, materials, power requirements, and environmental durability for marine applications (P.I.- 1.4.1)* *LO 6.3: Identify the need for appropriate guidance strategies for implementing marine robot application (P.I.- 3.1.1)* *LO 6.4: Apply principles of preventive engineering and sustainable development to an engineering activity relevant to the marine based robot. (P.I.- 6.4.2)* *LO 6.5: Create clear constructed, and well-supported documents and presentation for the existing marine robotic prototype. (P.I.- 9.1.2)* *LO 6.6: Analyse and comprehend technical information as to how marine robots communicate with surface control stations and other robots in the absence of traditional wireless communication methods for feasibility, viability, sustainability, etc. (P.I.- 11.3.2)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No. **P.I. Statement**

1.3.1 Apply fundamental engineering concepts to solve engineering problems.
1.4.1 Apply electrical engineering concepts to solve engineering problems.
2.2.1 Breakdown complex problem into interconnected sub parts and analyse by proper assumptions/ justification from information and resources.
2.2.4 Compare and contrast alternative solutions to select the appropriate methodology.
2.1.2 Identify engineering systems, variables, and parameters to solve the problems
2.4.3 Identify sources of error in the solution process, and limitations of the solution.

3.1.1 Recognize that need analysis is key to good problem definition.
3.2.2 Identify suitable criteria for evaluation of alternate design solutions
3.3.3 Identify relevant data from the given resources and arrive at the best fitting design solution for particular specifications.
6.1.1 Identify social, environmental and health related issues with the help of relevant viewpoints from stakeholders and propose engineering solutions.
6.1.3 Identify and evaluate the potential risks to human health and environment due to an engineering product design or modelling technique.
6.4.1 Describe and evaluate engineering principles for sustainable development pertaining to relevant fields.
6.4.2 Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline.
8.1.1 Recognize a variety of working and learning preferences; appreciate the value of diversity on a team.
8.3.1 Present results as a team, with smooth integration of contributions from all individual efforts.
9.1.2 Create clear, well-constructed, and well-supported written engineering documents and/or presentation.
9.2.2 Deliver effective oral presentations to technical or non- technical audiences.
11.3.2 Analyse sourced technical and popular information for feasibility, viability, sustainability, etc.

Course Outcomes: A learner will be able to -

1. Apply the basic concepts of robotics. (*LO 1.1- LO 1.5*)
2. Analyze the differential motion and statics in robotics. (*LO 2.1- LO 2.4*)
3. Select optimum path planning algorithm to determine parameters related to pick and place operations for workspace envelope. (*LO 3.1- LO 3.4)*
4. Apply and analyze the dynamics and control in robotics industries. (*LO 4.1 - LO 4.4*)
5. Develop self-learning ability to design and document an automated manipulator in advanced topic related to Robotic application based on automation, path planning algorithms, actuators, service and marine robots. (*LO2.5, LO 2.6, LO 3.5, LO3.6, LO 4.5, LO 5.1- LO 5.4, LO 6.1- LO 6.6)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ECPE5014.1	3		3			3					
ECPE5014.2	3	3									
ECPE5014.3	3		3								
ECPE5014.4	3	3									
ECPE5014.5	3		3			3		3	3		3
Average	3	3	3			3		3	3		3

Text Books :

1. R.K.Mittal and I.J.Nagrath, Robotics and Control, Tata McGraw Hill, New Delhi,4th Reprint, 2005.
2. Robert J Schilling, Fundamentals of Robotics, Prentice Hall India, 2000.
3. JohnJ. Craig ,Introduction to Robotics Mechanics and Control, Third edition, Pearson Education, 2009.
4. M.P.Groover, M.Weiss, R.N. Nageland N. G.Odrej, Industrial Robotics, McGraw-Hill Singapore, 1996.
5. Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, Introduction to Autonomous Mobile Robots", Bradford Company Scituate, USA, 2004
6. T. Fossen, "Guidance and Control of Ocean Vehicles", Chichester New York, US, 1994.
7. J. N. Newman, "Marine Hydrodynamics", MIT Press, USA, 1997.
8. T. Fossen, "Marine Control Systems: Guidance, Navigation and Control of Ships, Rigs and Underwater Vehicles", Marine Cybernetics, Trondheim, Norway, 2002.

Reference Books:

1. Ashitava Ghoshal, Robotics-Fundamental Concepts and Analysis', Oxford University Press, Sixth impression, 2010.
2. K. K.Appu Kuttan, Robotics, I K International, 2007.
3. Edwin Wise, Applied Robotics, Cengage Learning, 2003.
4. B.K.Ghosh, Control in Robotics and Automation: Sensor Based Integration, Allied Publishers,Chennai, 1998.
5. Riadh Siaer, The future of Humanoid Robots- Research and applications, Intech Publications, 2012.
6. K. D. Do and J. Pan, "Control of Ships and Underwater Vehicles: Design for Underactuated and Nonlinear Marine Systems", Advances in Industrial Control, 1st edition, Springer, Germany, 2009.
7. G. Griffiths, "Technology and Applications of Autonomous Underwater Vehicles", Ocean Science and Technology, Vol. 2, CRC Press, USA, 2002.
8. R. Sutton and G. Roberts, "Advances in Unmanned Marine Vehicles", IEE Control Series, Institution of Engineering and Technology, USA, 2006.

Other Resources:

1. NPTEL/ Swayam Course: Robotics and Control: Theory and Practice by Prof. N. Sukavanam and Prof.M. Felix Orlando, IIT Roorkee.
   Web Link: https://onlinecourses.nptel.ac.in/noc25_me69/preview

A. IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment-Theory (20 Marks)

Suggested breakup of distribution

a) In- class assignment based on flip class activity: 10 Marks
b) Open notes test: 05 Marks
c) Regularity and active participation: 05 Marks

3. Mid Semester Examination (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

B. END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20% to 30% weightage, and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Type	Course Code	Course Name	Credits
LBC	ECLBC506	HDL Programming Laboratory	2

Examination Scheme		
Term Work	**Practical /Oral**	**Total**
25	25	50

Pre-requisite:

1. ECPCC304: Digital Circuit Design
2. ECLBC302: Digital Circuit Design Laboratory
3. ECLBC405: Microcontrollers and Embedded System Laboratory

Program Outcomes addressed:

1. PO 3: Design/Development of Solutions
2. PO 4: Conduct investigations of complex problems
3. PO 5: Modern tool usage
4. PO 6:The Engineer and The World
5. PO 7: Ethics
6. PO 8: Individual and teamwork
7. PO9: Communication

Course Objectives:

1. To provide the learner the comprehension of HDL design flow.
2. To implement the Verilog design on programmable logic board using computer-based aids (Tools)
3. To identify test pattern and testing devices for the design implemented on programmable logic design

Module	Detailed Contents	Hrs
	This course strength the skill set in the field of Very Large-Scale Integration (VLSI) design. The programmable logic devices are the first choice of design engineer to embed the digital design in semiconductor technology to reduce time to market. This skill lab course also prepares them to keep pace with the changing trends of VLSI technology and the requirements of an ever-growing VLSI design industry. The HDL programming lab is also the prerequisite for system architecture, ASIC designs as well SoC field.	**02**
01.	**Introduction to HDL** ***Learning Objective/s:*** *To design the arithmetic circuits i.e., divisor, multiplier and common factor identifier using hardware descriptive language and debug, test /validate it using computer aided design tool.* **Contents:**	**6**

	HDL design flow, Lexical Conventions – Numbers, comments, whitespace, operators, strings, identifiers, keywords. Complier directives – define, include, ifdef, endif, else, timescale, System Tasks - display, monitor, time, stop, Modules, Gate level modeling, Behavioral Level Modeling, Data Flow Modeling, Test Bench ,HDL coding style . **Suggested list Experiments:** i. Develop the Verilog code of greatest common divisor. Write the test bench to simulate and verify the code. Use system task and complier directives in test bench to monitor the results. ii. Develop the Verilog code of least common multiple. Write the test bench to simulate and verify the code. Use system task and complier directives in test bench to monitor the results. iii. Develop a circuit to divide an 8-bit dividend by a 4-bit divisor to obtain a 4-bit quotient. Write the test bench to simulate and verify the code. Use system task and complier directives in test bench to monitor the results. iv. Develop of a multiplier for unsigned binary numbers that multiplies a 4-bit number by a 16-bit number to give a 20-bit product. Note: Any two experiments from above suggested list or similar experiments to be conducted . ***Self-Learning Topics:*** *Merits and demerits open source simulation tools for HDL.* ***Learning Outcomes :*** *A learner will be able to* *LO 1.1: Identify the Verilog construct, system task, complier directives and key words to edit, test, debug and simulate the arithmetic circuits design i.e., divisor, multiplier and common factor identifier by applying test bench using modern tool. (P.I.-4.2.1) (P.I.-4.3.1) (P.I.-5.1.1) (P.I.-5.3.3)*	
02.	**HDL code to IC** ***Learning Objective/s:*** *To design the combinational circuits i.e., divisor, multiplier and common factor identifier and implement it on programmable logic device with functional verification.* **Contents:** Programmable logic devices-FPGA and CPLD , FPGA Architectures and Technologies, FPGA Architectures and Technologies, Steps for HDL code to IC –Translate, Mapping, Place and Route, Configuration stream, downloading into PLD, Summary of the implementation. **Suggested list Experiments:** i. Implement greatest common divisor on programmable logic device. ii. Implement least common multiple on programmable logic device. iii. Implement divider on programmable logic device. iv. Implement multiplier on programmable logic device. Note: Any two experiments from above suggested list or similar experiments to be conducted . ***Self-Learning Topics:***	**6**

	Implement 4 bit adder ,subtractor, counter on programmable logic device. ***Learning Outcomes :*** *A learner will be able to* *LO 2.1: Apply HDL to bit stream generation steps to implement the digital design on programmable logic device and validate it by selecting appropriate testing and measuring devices such as logic analyzer or keys, LED, power supply, multi-meter with suitable test inputs(pattern). (P.I.-3.2.1) (P.I.-3.2.2) (P.I.-4.1.3) (P.I.-4.2.1).* *LO 2.2: Analyze the summary of implementation. (P.I.-4.3.3).*	
03.	**FSM using Verilog** ***Learning Objective/s:*** *To design control circuit for traffic lights, automobile warning indicators and score board and implement it on programmable logic device with functional verification.* **Contents:** Synchronous Sequential Circuit: Finite state machine, Sequential Verilog Construct for finite state machines, State machine synthesis, Timing Analysis of Logic circuits, Clock Skew, Clock Jitter, Test bench for sequential circuits. **Suggested list Experiments:** i. Design and implement traffic light controller for the intersection of street A and B. (Customized design problem). ii. Design and implement Scoreboard and controller. This can display scores from 0 to 99 (decimal). The input to the system should consist of a reset signal and control signals to increment or decrement the score. iii. Thunderbird car has three left (LA, LB, LC) and three right (RA, RB, RC) tail lights, which flash in unique patterns to indicate left and right turns. Design and Implement the controller to flash the desired pattern. Note: Any two experiments from above suggested list or similar experiments to be conducted . ***Self-Learning Topics:*** *Controller for streetlight Management System* ***Learning Outcomes :*** *A learner will be able to* *LO 3.1: Design and implement the control circuit i.e., Finite state machine using hardware descriptive language for road safety applications. (P.I.-3.1.6) (P.I.-3.2.1) (P.I-.6.1.1) (P.I-.6.2.1)* *LO 3.2: Test the design sustainability using specified procedure and analyze the summary of implementation (P.I.-4.2.1), (P.I.-4.3.3).*	**8**
04	**RISC Processor Design** *Learning Objective/s:* *To design 4-bit RISC processor using hardware descriptive language and implement/optimize the design implement it on programmable logic device with functional verification* **Contents:** RISC Philosophy, RISC Architecture – Memory, Register set, Instruction set, Instruction decoder, Data path, Control logic, Pipe line for Fetch, decode and execute, Primitives and its usage in design ,Efficient coding	**8**

	styles, Partitioning for synthesis, Pipelining, Resource sharing, Optimizing arithmetic expressions, Hardware Testing and Design for Testability, Boundary scan, built in self-Test	
	Suggested Experiment: Design 4-bit RISC processor with following features 1. 4 x 16 RAM interface – Data Memory 2. 8 x 32 ROM interface – Program Memory 3. 4 bit 8 Registers –R0 to R7 4. 4 bit ALU to perform addition, subtraction, logical operations (any 4) 5. Instruction Set - any 10 instructions to support ALU ,data moves	
	Self-Learning Topics: *Floating Point arithmetic* ***Learning Outcomes:*** *A learner will be able to* *LO 4.1: Design and implement the RISC processor using hardware descriptive language for given specification. (P.I.-3.1.6) (P.I.-3.2.1 (P.I.7.2.4)* *LO 4.2: Demonstrate/Present the design methods, test pattern, results and designed processor in teams. (P.I.-4.2.1) (P.I.-4.3.3) (P.I.-7.1.1)) (P.I.-8.2.4) (P.I.-8.3.1) (P.I.-9.1.2) (P.I.-9.2.2)*	
Total		**30**

P.I. No.	**P.I. Statement**
3.1.5	Explore and synthesize engineering requirements considering health, safety risks, environmental, cultural and societal issues
3.1.6	Determine design objectives, functional requirements and arrive at specifications
3.2.1	Apply design principles in engineering tools to build models/prototypes in order to develop engineering design solutions
3.2.2	Identify suitable criteria for evaluation of alternate design solutions
4.1.3	Apply appropriate instrumentation and/or software tools to make measurements of physical quantities
4.2.1	Design and develop an experimental approach, specify appropriate equipment and procedures, test vectors.
4.3.1	Use appropriate procedures, tools, and techniques to conduct experiments and collect data
4.3.3	Represent data (in tabular and/or graphical forms) to facilitate analysis and explanation of the data, and drawing of conclusions
5.1.1	Identify modern hardware and software engineering tools, techniques and resources for engineering activities.
5.3.3	Recognize sources of error in measurements, modelling or simulations and verify credibility of results.
6.1.1	Identify social, environmental and health related issues with the help of relevant viewpoints from stakeholders and propose engineering solutions.
6.2.1	Comprehend legal requirements relevant to engineering design and propose solution complying to engineering standards.
7.1.1	Follow ethical practices to create a document.
7.2.4	Use code of ethics while working with a diverse group of people for a team assignment/project.
8.2.4	Assess individual contributions to a team activity and provide feedback

8.3.1 Present results as a team, with smooth integration of contributions from all individual efforts

9.1.2 Create clear, well-constructed, and well-supported written engineering documents and/or presentation.

9.2.2 Deliver effective oral presentations to technical or non- technical audiences.

Course Outcomes: A learner will be able to -

1. Develop Verilog codes of arithmetic circuits with test bench and perform the functional simulation using computer aided design tools. *(LO 1.1)*
2. Design and implement arithmetic circuits on PLD and perform functional verification. *(LO 2.1, LO 2.2)*
3. Design the traffic controller, automobile indicators used for road safety applications. *(LO 3.1, LO 3.2)*
4. Design RISC Processor. *(LO 4.1, LO 4.2)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ECSBL603.1				3	3						
ECSBL603.2			3	3							
ECSBL603.3			3	3		3					
ECSBL603.4			3	3				3	3		
Average			3	3	3	3		3	3		

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. Digital Systems Design using Verilog , Charles H. Roth, Jr, Lizy Kurian John, Byeong Kil Lee, 2015,Independence : Nelson Engineering
2. Digital Design With an Introduction to the Verilog HDL, VHDL, and System Verilog, Morris Mano Michael D. Ciletti, Sixth Edition, Pearson

Reference Books :

1. Fundamentals of Digital Circuits, Anand Kumar, Fourth Edition, 2018, PHI learning
2. Digital Fundamentals, Thomas L. Floyd, Eleventh GlobalEdition,2015, Pearson Prentice Hall
3. Digital Electronics Principles and Applications, Mandal, First Edition, 2010, McGraw Hill Education
4. A Verilog HDL Primer, J. Bhasker, Third Edition, 1997, Star Galaxy Press

5. Embedded System, Raj Kamal , Fourth Edition,2020, McGraw Hill

Other Resources :

1. https://www.vlab.co.in/broad-area-electronics-and-communications

2. "Using Practical Examples in Teaching Digital Logic Design", Dr. Joseph P Hoffbeck, University of Portland

A. IN-SEMESTER ASSESSMENT (25 Marks)

Suggested breakup of distribution

a. Practical Exercises- 10 Marks

Students will be given number of experiments as mentioned in the syllabus. Each experiment carries 10 Marks. Average will be taken of all experiments. Students are expected to complete the task assigned in the experiment description, record observation, interpret results/conclusion and prepare a brief report as per requirement

b. Practical Test1– 5 Marks

Students will be assigned an experiment based upon the first 50 % of the practical experiments from the list, which they have to perform. Students will be evaluated by lab instructor based on the parameters mentioned in (a).

c. Practical Test2– 5 Marks

Students will be assigned an experiment based upon the last 50 % of the practical experiments from the list, which they have to perform. Students will be evaluated by lab instructor based on the parameters mentioned in (a).

d. Regularity and active participation - 5 Marks

B. END SEMESTER ASSESSMENT (Practical/Oral Examination) (25 Marks)

Students will be assessed based on three parameters:

- Interpretation of digital design
- Implementation and summary of the design
- Oral
- Students will be randomly allocated a problem statement to base on HDL programming laboratory work. The student ts will be asked to interpret and break down the design to write the HDL code of the given problem statement. The proposed breakup and HDL code will be checked by the examiners (Internal and External) and evaluated out of 5 Marks.
- Then the student will be allowed to for the code scripting, Functional verification of proposed design.
- Students will be allocated 1 hour to implement design. Both the examiners for its correctness verify the obtained result. The weightage of the implementation/verification is 10 Marks
- Students will then be appearing for Oral in front of both Internal and External examiners. The weightage of Oral will be of 10 Marks

Course Type	Course Code	Course Name	Credits
LC	ECLBC507	Digital Communication Laboratory	01

Examination Scheme		
Term Work	**Practical /Oral**	**Total**
25	25	50

Pre-requisite:

1. ESL206 -Basic Electronics Engineering Laboratory
2. ECLBC301- Electronic Devices and Circuits Lab
3. ECLBC404- Principles of Communication Lab

Program Outcomes addressed:

1. PO2: Problem analysis
2. PO3: Design/Development of solutions
3. PO4: Conduct investigations of complex problems
4. PO5: Modern tool usage
5. PO6: Engineer and the world
6. PO7: Ethics
7. PO8: Individual and team work
8. PO 9: Communication
10. PO11: Life-long learning

Course Objectives:

1. To familiarize students with source coding and error control coding techniques
2. To acquaint different line coding methods
3. To impart the conceptual knowledge on digital modulation and demodulation in time and frequency domain.
4. To enhance their problem- solving and analysis skills through different simulation tools for digital communication applications.

Module	Details	Hrs.
	Course Introduction This course is designed to provide students with a practical understanding of key digital communication techniques, with a special focus on shift keying methods such as Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), and Phase Shift Keying (PSK). Students will perform a series of experiments using trainer kits and software tools to simulate and implement these modulation techniques. These experiments will help bridge the gap between theoretical concepts and real-world applications, giving view of how digital signals are generated, transmitted, and received.	**01**
01.	**Source coding and channel coding-based experiments** ***Learning Objective:*** ***1. To interpret and observe different coding techniques.***	**08**

	2. To measure technical parameters of the observed signal and reach to a valid conclusion.	
	Task 1: **Implement source coding technique to compress a file and determine the code word.** *LO 1.1: Produce and validate results for entropy and efficiency in source coding techniques through skilful use of contemporary engineering techniques. Inculcate ability to work in a group with a mutually involvement manner and present individual contribution with valid reason. (P.I.- 2.4.2, 7.2.3, 8.2.4)* **Task 2:** **Implement an error correcting code for error detection and correction (Eg: Hamming code).** *LO 1.2: Analyse encoded data with error possibility and its limitation and adapt to the current technologies with new developments on error correcting codes. (P.I.- 4.3.2, 11.2.2)* **Task 3:** **Write a simulation code for generating a code word, detecting the error in the code word and correcting the error based on channel coding and decoding technique.** *LO 1.3: To use modern software tool to implement Channel encoding and decoding techniques to determine the code word and present individual contribution with valid reason. (P.I.- 5.1.2, 8.2.4)* *LO 1.4: Generate and prepare clear, well-constructed technical engineering documents on source and channel coding techniques. (P.I- 9.1.2)*	
	Self-Learning Topics: ***Insights on Octave software***	
02.	**Baseband modulation-based experiments**	**08**
	Learning Objective: ***1. To interpret and observe different line codes.*** ***2. To measure power spectral density of the observed signal and reach to a valid conclusion***	
	Task 4: **Use the trainer kit in a group for a digital pulse-based modulator/ demodulator including Line coding techniques and observe the waveforms at transmitter- receiver section.** *LO 2.1: Produce and validate results for digital pulse-based modulator/ demodulator, and line code generation system through skillful use of contemporary engineering techniques. Inculcate ability to work in a group with a mutually involvement manner and present individual contribution with valid reason. (P.I.- 2.4.2, 7.2.3, 8.2.4)* *LO 2.2: Use appropriate procedures, tools, and techniques to conduct experiments based on baseband modulations- demodulations and observe the results. Adapt to the current modulation techniques with additional features. (P.I.- 4.3.1, 11.2.2).* *LO 2.3: Demonstrate proficiency in using discipline-specific tools like DSO and spectrum analyzer to generate and display different line codes, digital pulse modulation- demodulation schemes and to effectively observe the associated power spectral density (PSD), signal efficiency and bandwidth. (P.I.- 5.2.2)*	
	Self-Learning Topics: ***Baseband receiver design***	
03.	**Bandpass modulation-based experiments**	**08**
	Learning Objective: ***1. To implement the circuit based on various parameters of modulation scheme to generate the modulated signals and measure the modulation characteristics.*** ***2. To simulate modulation schemes.***	
	Task 6:	

	Generation and detection of binary, quadrature and M-ary type of modulation and demodulation techniques based on trainer kit and observe the PSD to measure power and bandwidth of the system. *LO 3.1: Produce and validate results of key parameters such as power and bandwidth from the digital modulated system through skillful use of contemporary engineering techniques and present individual contribution with valid reason. (P.I.- 2.4.2, 8.2.4)* *LO 3.2: Recognize the need for various modulation techniques for reliable and efficient transmission of digital information over communication channels by trading off bandwidth efficiency, power efficiency, data rate, and error performance according to system requirements. (P.I.- 3.1.1, 6.4.2)* **Task 7:** **Simulate a digital modulation- demodulation based circuit/ Write a code and analyze digital modulation schemes using modern software tool.** *LO 3.3: Identify modern software engineering tools to simulate and analyze digital modulation schemes using design specific tools. Present results as a team, with smooth integration of contributions from all individual effort to synthesize the modulation- demodulation (P.I.- 5.1.1, 8.3.1)* *LO 3.4: Generate clear, well-constructed, and well-supported technical engineering document on various digital modulation techniques based on modern tools (P.I- 9.1.2)*	
	Self-Learning Topics: ***Insights on trainer kit and its use.***	
04.	**Spread spectrum modulation schemes**	**06**
	Learning Objectives: ***1. To develop, simulate and interpret the Pseudo-Random code based on spread spectrum parameters.*** ***2. To present the simulated results with teamwork.***	
	Task 8: **Generation of a Pseudo-Random (PR) Sequence based on trainer kit and observe the effects of PR sequence on the transmitted signal.** *LO 4.1: Produce and validate results of key parameters such as Jamming margin, noise and pseudo-noise sequence through skilful use of contemporary engineering techniques and present individual contribution with valid reason. (P.I.- 2.4.2, 8.2.4)* **Task 9:** **Simulate the Spread Spectrum technique for a data signal and demonstrate its resistance to noise.** *LO 4.2: Identify modern software engineering tools, techniques and resource to implement and analyze spread spectrum techniques and present results as a team, with smooth integration of contributions from all individual effort on executed circuits based on spread spectrum techniques (P.I.- 5.1.1, 8.3.1)* **Task 10:** **Simulate a GPS-like system with spread spectrum technique to understand how spread spectrum is used for high-accuracy positioning.** *LO 4.3: Recognize the need for PR sequence generator to overcome problems and apply principles of preventive measures and sustainability to the spread spectrum modulation technique application like GPS system (P.I.- 3.1.1, 6.4.2)*	
	Course Conclusion	**01**
	Total	**30**

Performance Indicators:

P.I. No.	P.I. Statement
2.4.2	Produce and validate results through skilful use of contemporary engineering techniques
3.1.1	Recognize that need analysis is key to good problem definition.
4.3.1	Use appropriate procedures, tools, and techniques to conduct experiments and collect data.
4.3.2	Analyse data for trends and correlations, stating possible errors and limitations
5.1.1	Identify modern hardware and software engineering tools, techniques and resources for engineering activities.
5.1.2	Use/adapt/modify/create tools and techniques to solve engineering problems
5.2.2	Demonstrate proficiency in using discipline-specific tools.
6.4.2	Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline.
8.2.4	Assess individual contributions to a team activity and provide feedback
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts
9.1.2	Create clear, well-constructed, and well-supported written engineering documents and/or presentation.
11.2.2	Adapt to the current technologies regarding new developments in relevant field

Course Outcomes:
A learner will be able to -

1. Analyze source and channel coding, modulation- demodulation and spread spectrum techniques on simulation software/ trainer kit. *(LO: 1.1, 2.1, 3.1, 4.1)*
2. Synthesize in a group the design of a source and channel coding, baseband-band pass modulation and spread spectrum technique to produce the desired results. *(LO: 1.2,1.3, 2.2, 2.3,3.3,4.2)*
3. Analyze the need for modulation techniques to overcome the associated problems by applying preventive measures to attain sustainability. *(LO: 3.2, 4.3)*
4. Prepare well well-documented report on experiments based on source and channel coding and modulation- demodulation techniques. *(LO: 1.4, 3.4)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ECLBC507.1	-	3	-	-	-	-	3	3	-	-	-
ECLBC507.2	-	-	-	3	3	-	-	3	-	-	3
ECLBC507.3	-	-	3	-	-	3	-	-	-	-	-
ECLBC507.4	-	-	-	-	-	-	-	-	3	-	-
Average	-	3	3	3	3	3	3	3	3	-	3

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Textbooks:

1. Lathi B P, and Ding Z-Modern Digital and Analog Communication Systems, Oxford University Press, Fourth Edition, 2017
2. Haykin Simon-Digital Communications, John Wiley and Sons, New Delhi, Fourth Edition, 2014

Reference Books:

1. S. R. S. Prasanna- Digital Communication Systems Engineering,
2. M. K. Simon, M. S. Alouini- Digital Communications: A Discrete-Time Approach
3. Henry R. Krieger- MATLAB for Engineers and Scientists
4. Andrea Goldsmith- Digital Communications: Fundamentals and Applications
5. Robert H. Morelos-Zaragoza- Practical Digital Communications

Suggested breakup of distribution

a. Practical Exercises- 10 Marks

Students will be given number of experiments as mentioned in the syllabus. Each experiment carries 10 Marks. Average will be taken of all experiments. Students are expected to complete the task assigned in the experiment description, record observation, interpret results/conclusion and prepare a brief report as per requirement.

b. Practical Test1– 5 Marks

Students will be assigned an experiment based upon the first 50 % of the practical experiments from the list, which they have to perform. Students will be evaluated by lab instructor based on the parameters mentioned in (a).

c. Practical Test2– 5 Marks

Students will be assigned an experiment based upon the last 50 % of the practical experiments from the list, which they have to perform. Students will be evaluated by lab instructor based on the parameters mentioned in (a).

d. Regularity and active participation - 5 Marks

B. END SEMESTER ASSESSMENT (Practical/Oral Examination) (25 Marks)

Students will be assessed based on three parameters:

- Concept/Theoretical knowledge
- Practical knowledge
- Oral

- Students will be randomly allocated an experiment from the list of laboratory exercises and will be asked to perform the same. The students will be asked to write the theory related to the experiment. The write-up is checked by the examiners (Internal and External) and evaluated out of 05 Marks.
- Then the student will be allowed to perform the experiment.
- Students will be allocated 1 hour to perform the experiment. The results are then checked by both the examiners for its correctness. The weightage of the successful done experiment is 10 Marks
- Students will then be appearing for Oral in front of both Internal and External examiners. The weightage of Oral will be of 10 Marks

Two examiners will do the evaluation.

Course Type	Course Code	Course Name	Credits
LBC	ECLBC508	Electromagnetic and Antenna Design Laboratory	01

Examination Scheme		
Continuous Assessment	**End-Semester Examination (ESE)**	**Total**
25	25	50

Pre-requisite:

1. BSC205 – Engineering Physics-II

Program Outcomes addressed:

1. PO2:Problem analysis
2. PO3:Design/Development of solutions
3. PO 4:Conduct investigations of complex problems
4. PO5: Modern tool usage
5. PO6:Engineer and the world
6. PO8: Individual and team work
7. PO9:Report writing
8. PO11:Life long Learning

Course Objectives:

1. To familiarize students with theoretical and practical expertise in designing, simulating, fabricating, testing, and optimizing antennas and related electromagnetic systems.
2. To summarize the concepts of array antennas such as analysis and synthesis of radiation patterns.
3. To prepare students to tackle real-world challenges in antenna design and electromagnetic wave propagation, with a strong understanding of both the simulation and hardware aspects of antenna system.
4. To enhance their problem- solving, measurement, and analysis skills while gaining hands-on experience in cutting-edge antenna technologies.

Module	Details	Hrs.
	Course Introduction This course bridges theory and practice, allowing the learner to explore the fascinating principles of electromagnetics and their application in designing and analyzing antennas. Through hands-on experiments and simulations, the learner will: • Understand the behavior of electromagnetic fields. • Learn how antennas transmit and receive signals effectively. • Gain proficiency in modern design tools and techniques for antenna analysis.	**01**

	The laboratory experience is designed to cultivate problem-solving skills and innovation, preparing you for real-world challenges in wireless communication, radar systems and beyond. Some of the most common and popular uses of antennas are for mobile phones, Wi-Fi routers, laptops, radios, TVs, cellular systems, satellite dishes and much more. Wearable antennas can be used for a variety of applications, including GPS trackers, glucose monitoring, breast cancer detection, and wearable thermometers.	
01.	**Fundamental concepts of Electromagnetics** ***Learning Objective:*** 1. *To develop in-depth understanding of the mathematical and physical principles governing EM wave behavior in various environments and to learn about the different regions in the electromagnetic field surrounding a source or antenna.* 2. *To apply the equation to determine power transmission in antenna systems.*	**06**
	Task I: **Use the trainer kit in a group to establish the relationship between field strength of radiated wave with distance and correlate it with inverse square law.** *LO1.1:Analyse concepts of electromagnetic to comprehend radiation principles and present individual contribution with valid reason.(8.2.4,2.2.2)* **Task II:** **Use the antenna trainer kit in a group to establish that the transmitting and receiving radiation patterns of an antenna are equal and correlate it with reciprocity theorem of antennas.** *LO1.2:Demonstrate relationship through measurements or simulations that the transmitting and receiving radiation patterns of an antenna are identical in well-created and supported documents. (4.1.4,9.1.2)*	
	Self-Learning Topics: Introduction to Static fields	
02.	**Types of Antennas and its parameters** Learning Objective:*To understand various types of antenna parameters, analyze and interpret the graphical representation of radiation patterns*.	**08**
	Spoken tutorials can be given on: Antenna Parameters: Isotropic antenna, Radiation pattern, radiation intensity,Beamwidth, directivity, Gain, beam efficiency, bandwidth, polarization, Input impedance, Antenna efficiency. Types of antennas: Wire Elements: Infinitesimal dipole, Wire dipole, Monopole antennas Broadband antenna :Helical and Log Periodic antenna Horn Antennas**:** E-Plane Sectoral Horn, H-Plane Sectoral Horn, Pyramidal Horn and Conical Horn Reflector Antennas: Plane Reflectors, Corner Reflectors and Parabolic Reflector Yagi antenna Patch Antenna: Microstrip antenna ,different types of Feeding Techniques.	

	Task III : Plotting of radiation pattern in a frequency range from 800MHz -1.25 GHz • monople and dipole antenna. • Yagi Uda antenna. • loop antenna • end side and broad side array They will also manually plot and measure antenna parameters : Gain,Directivity,Efficiency,RadiationPattern,bandwidth,Polarization,Beamwidth. *LO 2.1: Apply and analyze the practical methodology of electromagnetic principles for setting up and aligning antennas with transmitter and receiver systems and present individual contribution with valid reason.(2.4.4,4.3.1,8.2.4)* **Task IV** Plotting of radiation pattern for antennas from 1.25 GHz to 5.4 GHz. Measurements of gain , VSWR ,S parameters of microstrip antenna using Vector Network analyzer . *LO 2.2:Acquire resources to measure and plot the radiation pattern of different types of antennas (e.g., Yagi, horn, patch).(4.1.2,9.1.2)*	
	Self-Learning Topics: Anechoic chamber *https://www.youtube.com/watch?v=YI2l-ohdvVw* *Vector Network analyzer* ***https://www.youtube.com/watch?v=Sb3q8f0NBZc***	
03.	Software simulation of antennas ***Learning Objective:*** 1. *To become proficient in using industry-standard software tools for simulating antenna designs. for optimizing antenna designs, improving parameters like bandwidth, gain, and directivity.*	**06**
	A spoken tutorial session can be given to students before the simulation explaining the basic design principles of antennas design using HFSS. **Task V** Design of Rectangular Microstrip Patch antenna with different feed techniques viz., inset, coaxial probe, proximity coupled feed. The following parameter of antennas will be simulated and compared for better results in different feeding techniques. Gain,	

	Radiation Pattern, polarization, Beamwidth Front-to-back ratio.	
	Self-Learning Topics:*Microstrip patch design using HFSS design.* *https://www.youtube.com/watch?v=vHUbV_7f_dE*	
	Learning Outcomes: *A learner will be able to* *LO 3.1:To gain proficiency in using antenna design and simulation software and arrive at required specification.(5.2.2,3.1.6)* *LO 3.2:Develop the ability to interpret and analyze simulation results to refine antenna designs and present individual contribution with valid reason.(2.4.4,8.2.4)* *LO 3.3:Compare the effect of feeding techniques on parameters like return loss, bandwidth, and radiation efficiency and effectively document it.(2.2.4,9.1.2)*	
04.	Antenna fabrication (Course projects) ***Learning Objectives:*** 1. *Learn how to design and fabricate different types of antennas (e.g., dipole, patch, Yagi) for specific applications to help understand the material selection and structural requirements for antenna prototypes.* 2. *Gain knowledge of various testing equipment, including vector network analyzers (VNA), spectrum analyzers. And lso to learn various fabrication methods, such as PCB etching for microstrip antennas, metal bending for wire and monopole antennas.*	**08**
	Any one of the following. Task VI: Design and implement patch antenna for short-range wireless communication system. Design and analysis of a compact WiMAX and WLAN band notched planar mono pole antenna for Bluetooth applications. Design a Wide-band log periodic antenna operating from 800MHz to 6GHz with 10 dipoles is designed and is realized on 1.6 mm Epoxy FR4 substrate for field strength meter. Students will design,implement the antenna and prepare a technical paper.	
	Self-Learning Topics: ***Automated process of antenna fabrication*** ***https://www.youtube.com/watch?v=Wgw61-tSV3Q***	
	Learning Outcomes: *A learner will be able to*	

	LO 4.1:To gain insights into materials and techniques used for fabricating antennas, including PCB etching, metal machining, and soldering to implement the project effectively as a team(4.3.1,8.2.4) *LO 4.2:To gain knowledge of various testing equipment, including vector network analyzers (VNA), spectrum analyzers and effectively document the results through implementation of projects through adequate research literature review.(4.1.3,9.3.3,11.1.3)* *LO 4.3 :Ability to design an societal useful and real life application antenna like wifi application..(3.1.5,6.2.2,11.1.3)*	
	Course Conclusion	**01**
	Total	**30**

Performance Indicators:

P.I. No.	**P.I. Statement**
2.2.2	Identify resources to assemble/integrate information using mathematical tools.
2.2.4	Compare and contrast alternative solutions to select the appropriate methodology.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis
3.1.5	Explore and synthesize engineering requirements considering health, safety risks, environmental, cultural and societal issues
3.1.6	Determine design objectives, functional requirements and arrive at specifications
4.1.2	Examine the relevant methods, tools, and techniques of experiment, design, system calibration, data acquisition, analysis and presentation
4.1.3	Apply appropriate instrumentation and/or software tools to make measurements of physical quantities
4.1.4	Establish a relationship between measured data and underlying physical principles.
4.3.1	Use appropriate procedures, tools, and techniques to conduct experiments and collect data
5.2.2	Demonstrate proficiency in using discipline-specific tools.
6.2.2	Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public
8.2.4	Assess individual contributions to a team activity and provide feedback
9.1.2	Create clear, well-constructed, and well-supported written engineering documents and/or presentation.
9.3.3	Comprehend literature, carry out background search and prepare a paper/patent draft.
11.1.3	Develop ability to learn independently through methods distinct from instructor provided materials.

Course Outcomes: A learner will be able to -

1. To analyze given antennas for improved gain,efficiency and radiation pattern characteristics. *(LO1.1,LO 2.1,LO3.3*)
2. To design various types of antennas using software simulation tools.*(LO1.2,LO2.2,LO3.1 ,LO3.2)*
3. To fabricate an antenna for a given real life applications in a group.*(LO4.1,LO4.2,LO4.3)*

4. To prepare a technical paper/patent related to the antenna design and implementation. *(LO4.3)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ECLC508.1		3		3				3	3		
ECLC508.2			3		3			3	3		
ECLC508.3			3			3		3	3		
ECLC508.4			3			3		3	3		3
Average		3	3	3	3	3		3	3		3

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. Antenna Theory: Analysis and Design *by Constantine A. Balanis*
2. Antennas and Wave Propagation *by John D. Kraus and Ronald J. Marhefka*
3. Microwave Engineering *by David M. Pozar (for advanced concepts related to antennas and RF design)*

Reference Books :

1. Microstrip Antenna Design Handbook *by Ramesh Garg et al.*
2. Planar Antennas for Wireless Communications *by Kin-Lu Wong*
3. Modern Antenna Design *by Thomas A. Milligan*
4. Handbook of Antenna Design" by A.W. Rudge, K. Milne, A.D. Olver, and P. Knight
5. Small Antennas: Miniaturization Techniques & Applications" by Volakis, Chen, and Fujimoto

Other Resources :

1. Coursera: *Antenna Design and Analysis* by top universities https://www.coursera.org/learn/microwave-antenna
2. edX: *Electromagnetic Waves and Antennas* by MIT https://ocw.mit.edu/courses/6-013-electromagnetics-and-applications-spring-2009/
3. Udemy: *Practical Antenna Design: From Theory to Simulation* https://www.udemy.com/course/antennas-fundamental-parameters-theory-and-design
4. NPTEL (India): *Antenna Design and Applications* https://archive.nptel.ac.in/courses/108/101/108101092/

IN-SEMESTER ASSESSMENT (75 MARKS)

a. Practical Exercises- 10 Marks

Students will be given number of experiments as mentioned in the syllabus. Each experiment carries 10 Marks. Average will be taken of all experiments. Students are expected to complete the task assigned in the experiment description, record observation, interpret results/conclusion and prepare a brief report as per requirement.

b. Students need to write a paper based on their course project implementation. 10 marks

This paper will be in IEEE format.

c. Regularity and active participation - 5 Marks

B. END SEMESTER ASSESSMENT (Course Project Evaluation) (25 Marks)

Two examiners, one Internal and one External will do the evaluation.
Students will be assessed based on these parameters:

- Problem formulation
- Design
- Simulation skills
- Implementation of design
- Quality of paper.

Students will then be appearing for presentation of their course projects in front of both Internal and External examiners.

Course Type	Course Code	Course Name	Credits
AEC	AEC 502	PROFESSIONAL COMMUNICATION & ETHICS-2	02

Examination Scheme					
Distribution of Marks			**Exam Duration (Hrs.)**		**Total Marks**
In-semester Assessment		**End Semester Examination (ESE)**			
Continuous Assessment	**Mid-Semester Exam (MSE)**		**MSE**	**ESE**	
50	--	--	--	--	50

Program Outcomes addressed:

1. PO7 : Ethics
2. PO8 : Individual and Teamwork
3. PO9 : Communication
4. PO11: Life-long learning

Course Objectives:

1. To inculcate in students, professional and ethical attitude, effective communication skills, team work and a multidisciplinary approach.
2. To provide students with an academic environment where they will be aware of the need for excellence, leadership and lifelong learning to build a successful academic & professional career.
3. To create awareness about professional ethics and codes of professional practices.
4. To prepare students for a successful academic and/or professional career that meets the global academic and/or corporate requirement by providing students to work on multidisciplinary projects as part of different teams to enhance their team building capabilities like leadership, motivation, teamwork, and other interpersonal skills.

Module	**Details**	**Hrs.**
	Course Introduction The curriculum of Professional Communication and Ethics-2 is designed to provide students with an academic environment that promotes a professional and ethical attitude as they participate in individual and team activities. The practical sessions will supplement the learner's interactive competence and confidence to respond appropriately and creatively to the implied challenges of the global industrial and corporate requirements. The curriculum will create an awareness of professional ethics and the standard code of conduct. It will further inculcate within the budding engineer the social commitment as responsible technical citizens. It will enhance the learner's team building capacities,	**01**

	interpersonal skills and leadership skills so as to become a well-rounded professional in their field of expertise.	
01.	**EMPLOYABILITY SKILLS** ***Learning Objectives:*** *1. Customised writing skills and Content Development: To develop effective writing skills to craft a clear, concise, and compelling Statement of purpose, formal letters and resumes for a specific purpose.* *2. To instil productive and efficient skills to participate confidently and constructively in group discussions and interviews for employability* *3. To inculcate Ethical Communication & Empathetic Listening*	
	Contents: **1.1 Business Correspondence** o Letter Writing (Principles, Format, Structure, Content, Types) o Job Application Letter o Joining Letter o Resignation Letter o Resume Writing **1.2 Statement of Purpose/ Letter of Intent or Interest** o Purpose o Elements of SOP/LOI o Structure o Tips for writing effective and ethical SOP/LOI **1.3 Verbal Aptitude Tests** modeled on CAT,GRE,GMAT,IELTS **1.4 Group Discussions**: Purpose, parameters of evaluating, Types of GDs (Traditional, Case-based & Role Plays), GD Etiquettes, and Importance of inclusivity, respectful listening and expression of diverse ideas for a common goal. **1.5 Personal Interviews:** Preparation, Types of questions, Types of interviews and modes of interviews. Types: Structured, Stress, Behavioural, Problem Solving & Case-based, Modes of Interviews: Face-to-face (One-to one and Panel) Telephonic, Virtual **1.6 Significance of Ethical approach during Group Discussions and Interviews** o Respectful listening o Speaking Assertively o Inclusivity of diverse individuals o Mindfulness and openness to different ideas o Common Goal of Consensus	**03**
	Self-Learning Topics: ***Watch recordings of professional interviews from online resources.(ex: Civil Service interviews), IIM and UPSC GDs***	

	Activities: *1. Prepare an SOP for admission procedure in a reputed university.* *2. Participate in GDs on a given topic followed by Mock Interview.* *3. Attempt Verbal Aptitude and Comprehension Tests.* *4. Write a Job Application/Resignation/Request/Enquiry letter in the learned format* *5. Write a Resume as a fresh graduate trainee for a specific post.*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Write clear, concise and professional letters of various types that effectively convey information, build relationships and achieve professional objectives.(9.1.3, 9.2.3, 9.3.2, 11.1.1)* *LO 1.2: Rationally apply gained knowledge of group discussions and aptitude tests for continuous improvement and professional growth in academia and industry. (8.1.2, 8.2.1, 11.1.1.)* *LO 1.3: Exhibit the ethical code of conduct by treating all team mates with respect and dignity, by listening attentively to each member, and encouraging diversity of ideas during a GD. (7.3.1, 8.1.1, 8.2.2,8.2.3, 8.2.4, 9.2.3)* *LO 1.4: Demonstrate through group discussions and mock interviews, the ability to effectively identify unethical conduct and arrive at ethical decisions through strong leadership skills and respectfully lead a team or oneself to the desired goal. (7.1.1,8.1.2,8.2.1,8.2.3, 8.2.4, 8.3.1,9.2.2, 9.2.3)* *LO 1.5: Exhibit a calm demeanor by effectively preparing for competitive exams through mock tests which contain comprehending logical instructions, analysis, problem solving and verbal aptitude assessment (8.2.4, 9.1.1,11.1.1)*	
02.	**INTERPERSONAL SKILLS & ETHICS** ***Learning Objectives:*** 1. *Develop Problem Solving & Critical Thinking: To help budding engineers understand the importance of interpersonal skills and demonstrate creativity, resourcefulness, along with enhanced communication in personal and professional settings.* 2. *Self-Management & Ethical Awareness: To create awareness of Ethical and Social Responsibility towards individual and society by fostering self and team management leading to increased productivity and job readiness.*	**03**
	Contents: **2.1 Interpersonal Skills (implementation in all AE activities)** o Emotional intelligence o Effective Leadership o Team Building o Conflict Management o Negotiation & Ethical Conflict Resolution o Time management, o Assertiveness **2.2 Importance of Ethics in Interpersonal Relations** o Ethical and Inclusive Decision making. o Ethics in relation to Emotional Quotient	

	Self-Learning Topics: Follow industry leaders and experts on social media or read articles on topics related to corporate ethics and social responsibility. ***Activity:*** 1. *Listen to podcasts that discuss ethics, communication and interpersonal skills, such as "The TED Radio Hour" or "How I Built This" and conduct a GD on its learnings.*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply the learned interpersonal skills in various A.E. activities such as Report presentations, drafting business plans and SOP in an accepting, respectful and inclusive manner. (7.3.1,8.1.1, 8.1.2, 8.2.1, 8.2.2, 9.2.1, 9.2.3)* *LO 2.2: Apply the awareness of ethics while participating in a well-organized, time bound and constructive GD on topics raising ethical and moral concerns. (7.2.2, 7.3.1,8.2.1, 8.3.1, 9.2.3)* *LO 2.3: Apply empathetic and effective speaking skills utilizing ethical values and principles to resolve any social problem while working in a diverse team for group activities. (7.2.2, 7.3.18.1.1, 8.2.1, 8.2.2, 8.2.3, 9.2.1, 9.2.2.)* .	
03.	**ADVANCED TECHNICAL WRITING:PROJECT/PROBLEM BASED LEARNING** ***Learning Objective:*** *1. Structure & Organisation: To enable the learner to craft a well-structured technical report, utilizing a logical flow with clear introduction, body and flow, ensuring clarity and coherence in their writing.* *2. Effective Communication: To enhance the ability to communicate complex information clearly and concisely, using relevant visual aids and making the information accessible to technical and non-technical audience.*	**03**
	Contents: **3.1 Technical/Academic Report** o **Classification of reports on the basis of**: Subject Matter, Time Interval, Function, Physical Factors. o **Parts of a long formal report**: Front Matter, Main Body and Back Matter. o **Language and style of Reports:** Grammar, Tone, Style, Vocabulary, Format of the report from title page to appendices. **3.2 Definition, purpose and types of Proposal** o Parts of a Proposal**:** Elements, Scope and Limitations, Conclusion o Technical Proposal/Synopsis **3.3 Technical Paper Formats (APA/IEEE)** **Parts of a Research paper**: o Title Page o Abstract, o Introduction o Problem Statement/Hypothesis o Research methods, o Data Search (Primary/Secondary) o Quantitative/ Qualitative Analysis o Discussion,	

	○ Delimitations, ○ future scope and ○ References. ○ Appendix ○ Acknowledgement **3.4 Significance of Presenting and Publishing a Research Paper** ○ Reading Secondary Data ○ Looking for research gaps ○ Understanding Need to fill research gap ○ Creating a Problem Statement ○ Writing a Synopsis ○ Writing an academic paper in the APA/IEEE format	
	Self-Learning Topics: ***Read academic research papers and look for gaps in the research area.*** ***Activity*:** *1. Prepare an Academic Research Paper on any technical problem of your choice with solutions for the same and present it using ICT. [Team of 6/ Research Paper + Presentation & Group Dynamics]*	
	Learning Outcomes: *The learner will be able to* *LO3.1: Write, individually or as a team, a research paper, with logical & rational progression of ideas, effectively, in a time bound manner to everyone's understanding (8.3.1, 9.1.3, 9.2.3)* *LO3.2: Read, comprehend, and interpret previous research/ secondary source data and clearly state the purpose of research using the IEEE format. (9.1.1,9.1.3,11.3.1)* *LO3.3: Demonstrate the ability to use critical thinking to find gaps in research, interpret the technical and non-technical data and present it with clarity. (9.1.1, 9.1.3, 11.1.2, 11.3.1)* *LO3.4: Apply gained knowledge of technical writing for continuous improvement in academia and professional growth. (11.1.1)*	
04.	**TECHNICAL/BUSINESS PESENTATIONS** ***Learning Objectives:*** *1. The development of effective presentation structure and content for academic and technical presentation with the help of ICT* *2.Capacity building for delivering confident and persuasive presentation to both technical and non-technical audience individually or in a team.*	**02**
	Contents: **4.1 Effective Presentation Strategies:** ○ Purpose of a presentation, ○ Understanding the audience, location and the event, ○ Arranging the material, structuring the presentation, ○ Making effective slides and platform skills. **4.2 Group Presentations:** ○ Working with a mixed team (Diversity) ○ Sharing responsibility in a team (Delegation) ○ Creating the content together (Uniformity) ○ Transition phases and Coordination. (Teamwork)	

	○ Time Management (Individual and Team) **4.3 Individual Presentations:** ○ Introduction of Self and Topic ○ Understanding the audience, building rapport ○ Time Management ○ End with Q n A, Feedback	
	Self-Learning Topics: *Watch YouTube videos of presentations like TED TALKS on motivational topics* ***Activity*:** *1. Prepare an academic research paper on any one Technical problem of your choice with solutions for the same and present it using ICT. [Team of 6/ Research Paper + Presentation & Group Dynamics]*	
	Learning Outcomes: *A learner will be able to* *LO4.1: Demonstrate efficacious and seamless presentation skills to all audiences as an individual and a team with impeccable leadership qualities through proper delegation, problem solving and management (8.1.2, 8.2.1,8.3.1, 9.1.3, 9.2.2, 9.3.2)* *LO4.2: Engage with a diverse team and a mixed audience, during presentations, keeping in mind their uniqueness and differences. (7.3.1.,8.1.1,8.1.2,8.3.1,9.2.2, 9.2.3)*	
05.	***CORPORATE ETHICS*** ***Learning Objective/s:*** 1. *Ethical Principles & Frameworks: To aid the learner to differentiate between various codes of conduct and ethics in the social and professional world.* 2. *Analyse & Resolve Ethical Dilemmas: To enforce the significance of ethical citizenry & generate awareness on the importance of IPR and its consequences*	**02**
	Contents: **5.1. Intellectual Property Rights : Significance, Duration, Laws** ○ Copyrights ○ Trademarks ○ Patents ○ Geographical Indication ○ Industrial Designs ○ Trade Secrets **5.2. Start- Up Skills:** ○ Financial Literacy ○ Risk Assessment ○ Data Analysis. **5.3. Gender Equity & Inclusivity at the Work Place** ○ Study on Cases related to Gender Equity in India & Global ○ Corporate Social Responsibility ○ Inclusivity at the work place ○ Corporate Code of Conduct	
	Self-Learning Topics: Read a biography on a Business Leader/Philanthropist, Collect information on some failed startups. Assess and analyse the reasons for their failure.	

	Activity: 1. *Find and analyse a Case Study on the topic on Gender Equity & Inclusivity; Generate a solution based article in APA format and present before an audience (10M)* 2. *Assess and analyse a failed start up. Find gaps leading to failure. Give viable solutions; Generate an article in APA format; present before an audience. (10M)*	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Utilise professional, moral and ethical principles to identify wrong conduct and suggest ethical solutions through IPR, Gender Equity and Corporate ethics (7.1.1, 7.2.2, 7.3.1)* *LO 5.2: Critically evaluate various socioeconomic, gender issues of discriminatory nature, while emulating equality and open mindedness in all teams, sectors and activities. (7.1.1, 7.2.2,7.3.1, 8.1.1, 8.1.2, 9.2.3)* *LO 5.3: Employ the awareness of IPR to avoid or solve unethical practices in professional life by following standard rules and practices and emerge as a productive team member and a progressive leader. (7.1.1,7.2.2, 8.2.1, 8.2.2, 11.1.1)* *LO 5.4: Assess a failed business plan, analyse reasons for failure and suggest viable solutions as a team keeping in consideration both the individual and team effort. (8.2.1, 8.3.1,9.1.3, 11.1.2)*	
	Activities for Ability Enhancement (Practical Sessions):	**30**
	Contents: 1. *Write a job application letter, a joining letter, a letter of apology, a request letter. Attach a Resume to the Job Application letter. Follow Standard formats and protocols for each document. (5M)* 2. *Prepare an Academic Research Paper on any one Technical problem of your choice with solutions for the same and present it using ICT. [Team of 6/ Research Paper (5M) + Presentation & Group Dynamics (5M)]* 3. *Prepare an SOP for admission procedure in a reputed university. (5M)* 4. *Participate in GDs on given topic followed by Mock Interview ((10 M)* 5. *Attempt Verbal Aptitude and Comprehension Tests(5M)* 6. *Find and analyse a Case Study on the topic on Gender Equity & Inclusivity; Generate a solution based article in APA format and present before an audience (10M)* ***OR*** *Assess and analyse a failed start up. Find gaps leading to failure. Give viable solutions; Generate an article in APA format; present before an audience. (10M)* 7. *Active Participation & Regularity (5M)*	
	Activities will start in the inverted pyramid, viz., with group activities first so as to build confidence and ending with solo presentations in the form of research paper presentation or Gender Equity presentation. *Group Discussion, Interview Skills, Presentation skills will have at least three mock drills before the final assessment of the same.* *Rigorous development of the English language, social and professional etiquette will be the praxis*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
7.1.1	Identify situations of unethical professional conduct and propose ethical alternatives
7.2.2	Examine and apply moral & ethical principles to known case studies
7.3.1	Apply and exhibit universal human values and a diverse and inclusive mind-set, free of discrimination
8.1.1	Recognize a variety of working and learning preferences; appreciate the value of diversity on a team
8.1.2	Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal.
8.2.1	Demonstrate effective communication, problem-solving, conflict resolution andleadership skills
8.2.2	Treat other team members respectfully
8.2.3	Listen to other members
8.2.4	Maintain composure in difficult situations
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts
9.1.1	Read, understand and interpret technical and non-technical information
9.1.3	Create flow in a document or presentation - a logical progression of ideas so that themain point is clear
9.2.1	Listen to and comprehend information, instructions, and viewpoints of others
9.2.2	Deliver effective oral presentations to technical and non-technical audiences
9.2.3	Apply efficient and effective communication, keeping in mind the diversity and uniqueness in the team.
9.3.2	Use a variety of media effectively to convey a message in a document or a presentation
11.1.1	State the rationale for the requirement for continuing professional development
11.1.2	Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to close this gap
11.3.1	Source and comprehend technical literature and other credible sources of information

Course Outcomes: A learner will be able to -

1. Communicate and present effectively and ethically with mixed media in both oral and written forms business reports and documents which will in turn provide a solid foundation for their future managerial roles. (*LOs 1.1, 1.2, 1.4, 2.1, 2.2, 3.1, 3.2, 4.1, 4.2, 5.1)*
2. Exhibit the skill set required for successful employability while expressing ethical, assertive and inclusive leadership skills. (*LOs 2.1, 2.2, 2.3, 3.2, 4.2, 4.3, 5.2)*
3. Develop a critical thinking acumen to prepare for and give various competitive exams, emerge successful in group discussions and conduct healthy debates. (*LOs 1.3, 2.1, 2.2, 2.3, 3.1, 4.2)*
4. Develop creative and mindful thinking while demonstrating the knowledge of professional and personal etiquettes & ethics, such as diversity and inclusivity, in the global environment. (*Los 1.2, 2.2, 2.4,1.3, 3.2, 4.3, 5.1, 5.2, 5.3, 5.4)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
AEC502.1							3	3	3		3
AEC502.2							3	3	3		3
AEC502.3							2	3	3		3
AEC502.4							3	3	3		3
Average							3	3	3		3

Reference Books:

1. Arms, V. M. (2005). *Humanities for the engineering curriculum: With selected chapters from Olsen/Huckin:*
2. *Technical writing and professional communication, second edition*. Boston, MA: McGraw-Hill.
2. Bovée, C. L., &Thill, J. V. (2021).
3. *Business communication today*. Upper Saddle River, NJ: Pearson.
4. Butterfield, J. (2017). *Verbal communication: Soft skills for a digital workplace*. Boston, MA: Cengage Learning.
5. Masters, L. A., Wallace, H. R., & Harwood, L. (2011).*Personal development for life and work*. Mason: South Western Cengage Learning.
6. Robbins, S. P., Judge, T. A., & Campbell, T. T. (2017). *Organizational behaviour*. Harlow,

England: Pearson.
7. Meenakshi Raman, Sangeeta Sharma (2004) Technical Communication, Principles and Practice. Oxford University Press
8. Archana Ram (2018) Place Mentor, Tests of Aptitude For Placement Readiness. Oxford University Press
9. Sanjay Kumar &PushpLata (2018). Communication Skills a workbook, New Delhi: Oxford University Press.

Other Resources :

1. NPTEL Course: https://archive.nptel.ac.in/courses/109/104/109104030
   Dept. of Humanities and Social Sciences, IIT Kanpur, A Course on Communication Skills

CONTINUOUS INTERNAL ASSESSMENT (50 Marks)

1. Assignments on Resume Writing and Business Correspondence (5M)
2. Prepare an Academic Research Paper (3500-4000 words) on any one socio-technical problem of your choice with solutions for the same and present it using ICT. [Team of 6/ Research Paper/ IEEE (5 M) + Presentation & Group Dynamics. (5M)]
3. Prepare an SOP for admission procedure in a reputed university. (5M)
4. Participation in Final GD on concrete/abstract topic followed by Mock Interview. (10M)
5. Verbal Aptitude Tests (5M)
6. Analyse a Case Study on the topic of Gender Equity & Inclusivity and present (APA) OR
   Analyse a failed start up present your case to a mixed audience (APA) (10M)
7. Regularity and Active participation (5M)

Course Type	Course Code	Course Name	Credits
MNP	ECMNP503	MINI PROJECT- 2A	01

Program Outcomes addressed:

1. PO1 : Engineering knowledge
2. PO2 : Problem Analysis
3. PO3 : Design/Development of Solutions
4. PO4 : Conduct investigations of complex problems
5. PO5 : Modern Tool Usage
6. PO6 : The Engineer & World
7. PO7 : Ethics
8. PO8 : Individual & team work
9. PO9: Communication
10. PO10: Project Management & Finance
11. PO11: Life-long learning

Course Objectives:

1. To guide students in identifying societal or research needs and formulating them into problem statements.
2. To facilitate problem-solving in group settings.
3. To apply basic engineering principles to address identified problems.
4. To foster self-learning and research skills.

Course Outcomes:

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

1. Identify problems based on societal or research needs and methodology for solving them.
2. Apply knowledge and skills to solve societal problems collaboratively.
3. Develop interpersonal skills necessary for teamwork.
4. Analyze, verify, and validate results effectively through various methodologies, including, test cases/benchmark data/theoretical/inferences/experiments/simulations, etc.
5. Evaluate the societal and environmental impacts of proposed solutions.
6. Adhere to standard engineering practices.
7. Excel in written and oral communication by technical report writing, oral presentation, and publishing results in
   - Research/white paper/article/blog writing/publication, etc.
   - Business plan for entrepreneurship product creation
   - Patent filing/copyright.
8. Gain technical competencies by participating in competitions, hackathons, etc.
9. Demonstrate lifelong learning capabilities through self-directed group projects.
10. Apply project management principles effectively.

Guidelines for the Mini Project

- Mini project may be carried out in one or more form of following:
  Product preparations, prototype development model, fabrication of set-ups, laboratory experiment development, process modification/development, simulation, software development, integration of software (frontend-backend) and hardware, statistical data analysis, creating awareness in society/environment etc.
- Students must form groups of 3 to 4 members either from the same or from different departments.
- Groups should conduct surveys to identify needs and develop problem statements in consultation with faculty.
- An implementation plan in Gantt/PERT/CPM chart format covering weekly activities must be submitted.
- Each group must maintain a logbook to record weekly progress, to be verified by the faculty supervisor.
- Faculty input should emphasize guiding by faculty and self-learning by group members.
- Groups should propose multiple solutions, select the best one in consultation with the supervisor, and develop a working model.
- The solution to be validated with proper justification and report to be compiled in standard format of the Institute. Software requirement specification (SRS) documents, research papers, competition certificates may be submitted as part of annexure to the report.
- With the focus on self-learning, innovation, addressing societal/research/innovation problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality be carried out in two semesters by all the groups of the students.
- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above, gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on a case by case basis.

In-Semester Continuous Assessment and End-Semester Examination Guidelines

- The Head of the Departments will assign a guide to each of the mini-projects and shall form a progress monitoring committee. The guide will carry out weekly monitoring of the project's progress. The committee shall carry out in-semester project evaluation based on presentations with a minimum of two evaluations per semester.
- Assessment will be based on individual contributions, understanding, and responses to questions asked.
- Continuous Assessment marks distribution in semester V (50 marks):
  - 05 marks for the Topic Approval Presentation in front of the progress monitoring committee
  - 20 marks for the Mid-Semester Progress Presentation in front of the progress monitoring committee
  - 20 marks for the Final Report & Presentation
  - 05 marks for Regularity and active participation

The review/progress monitoring committee will assess projects based on the following criteria.

Semester V:

- Theoretical solution completion, including component/system selection/design of software solution and cost analysis.
- Two reviews will occur:
  - The first review will focus on finalizing the problem statement (topic approval).
  - The second review will centre on finalizing the proposed solution.

In addition to above mentioned points, the following performance criteria shall be included during in-semester continuous assessment:

1. Quality of survey and need identification.
2. Clarity and innovativeness in problem definition and solutions.
3. Requirement gathering via SRS/feasibility study, cost-effectiveness, and societal impact of proposed solutions.
4. Completeness and full functioning of the working model.
5. Effective use of skill sets and engineering norms.
6. Verification & validation of the solutions/test cases.
7. Individual contributions to the group.
8. Clarity in written and oral communication.
9. Participation in technical paper presentation/project competitions/hackathon competitions, etc.

Course Type	Course Code	Course Name	Credits
HSS	HSS502	Entrepreneurship	02

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
50	--	--	--	--	50

Pre-requisite: NIL

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/ Development of Solutions
4. PO6: The Engineer & The World.
5. PO7: Ethics
6. PO10: Project Management & Finance
7. PO11: Life-long learning

Course Objectives:

1. To develop Entrepreneurial mindset amongst the learners.
2. To promote Entrepreneurship as life-skills to improve quality of life, skills of creation and management of entrepreneurial pursuits.
3. To explore paths of the innovation through the creative problem-solving skills
4. To familiarize with the steps involved in 'idea to product' development.
5. To get acquainted with the preparation of pitch at ideation, business idea presentation and funding stages

Module	Details	Hrs
00	**Course Introduction:** This course aims to equip individuals with the knowledge, skills, and mindset needed to identify and pursue new business opportunities. It aims to foster an entrepreneurial culture and mindset to help develop the next generation of entrepreneurs who can create jobs, drive economic growth, and contribute to the society. Entrepreneurship is a life skill that will help an individual succeed in a variety of scenarios, both personal and professional. By its very nature, entrepreneurship is an interdisciplinary field that draws from a range of disciplines, including business, economics, engineering, and social sciences. Some of the key topics covered in Entrepreneurship Course include opportunity recognition, market research, business planning, financing, marketing, and management while emphasizing the development of critical thinking, creativity, risk-taking, and problem- solving skills.	1

1	**Fundamentals of Entrepreneurship**	5-6
	***Learning Objectives**:* • *To gain knowledge about the concepts and principles of entrepreneurship, including opportunity recognition and value creation.* • *To develop an entrepreneurial mindset and skills that will enable them to identify, evaluate, and pursue viable business opportunities with confidence.*	
	Contents: Introduction to Entrepreneurship, Entrepreneurial Mindset, Opportunity Identification, Market Analysis & Customer Research, Business Models & Go-to-Market, Funding and Financial Management, Marketing Aspects, Scaling the Venture and Growth Strategies: *Note:* A real life case study covering key elements of the module shall be covered.	
	Learning Outcome: *The learner would be able to* • *Understand the concept of Entrepreneurship* • *State the myths, advantages and limitations of Entrepreneurship* • *Interpret and analyze market research data and customer analysis to make informed business decisions.* • *Discuss the steps in the process of Entrepreneurship*	
2	**Technological Innovation and Entrepreneurship**	4-5
	Learning Objectives: • *To enhance creative problem-solving skills and to examine the importance of innovation in business success.* • *To identify the types of Innovation* • *To gain knowledge for taking an idea to product development stage while protecting the idea with IPR.*	
	Content: Foundations of Creativity and Innovations, Creative thinking process, Types of Innovation: Incremental, Disruptive, and Radical, Innovation Process: from idea to execution; Protecting ideas - Patents and IPR. Exploring Technological Innovation through Case Studies.	
	Learning Outcome: *The learner would be able to* • *Use their understanding of the role Technological innovation plays in driving business success.* • *To formulate steps for taking an idea to product stage with necessary patents*	
3	**Ideation, Prototyping, Testing, Validation and Commercialisation**	5-6
	Learning Objectives: • *Experiment to test Minimum Viable Products (MVPs) and validate business ideas.* • *To formulate a Build-Measure-Learn feedback loop for continuous improvement.*	

	Contents: Identifying customer needs and problems to solve, Ideation, Concept Development, Design Thinking, Prototyping, Minimum Viable Product (MVP), Testing, and Iterations. Understanding the Market, customer feedback and refinement of business idea based on feedback. *Note:* A real life case study covering key elements of the module shall be covered.	
	Learning Outcome: *The learner would be able to* • *Select specific measures to design, test, and validate Minimum Viable Products (MVPs) to assess business ideas.* • *Interpret the learnings from the build-measure-learn feedback loop to facilitate continuous improvement and learning.*	
4	**Financial Resources**	3-4
	Learning Objectives: • *Describe the key concepts, and strategies related to fundraising for entrepreneurial ventures.* • *Compare various funding sources, including angel investors, venture capitalists, grants, and crowdfunding platforms.* • *Devise and create compelling investor pitches, develop financial projections.*	
	Contents: Funding new ventures – bootstrapping, crowd sourcing, Angel investors, VCs, debt financing, and due diligence; Raising fund during life-cycle of a new ventures. *Note:* A real life case study covering key elements of the module shall be covered.	
	Learning Outcome: *The learner would be able to* • *Recognize various fundraising strategies and techniques, enabling s to choose the most appropriate funding sources for their entrepreneurial ventures.* • *Sketch effective pitches and fundraising campaigns tailored to different types of investors and funding sources, ensuring successful capital-raising efforts.*	
5	**National Entrepreneurial Culture**	4-5
	Learning Objectives: • *To gain knowledge of legal and regulatory requirements for startups, including compliance with relevant regulations.* • *To identify the various government initiatives to develop the start-up ecosystem.*	
	Contents: Entrepreneurial Ecosystem in India, Key regulations and legal aspects, Forms of Business Ownership, MSMED Act 2006 and its implications, schemes and policies of the Ministry of MSME, role and responsibilities of various government organisations, departments,	

	banks etc. Government incentives for entrepreneurship, Incubation, & Acceleration.	
	Learning Outcome: *The learner would be able to* • *Describe the current scenario of Entrepreneurial activity in India.* • *To state legal and regulatory requirements and compliances for start-ups.* • *To state the various government initiatives to support the entrepreneurs.*	
6	**Start-up Case Studies**	3-4
	Learning Objectives*:* *To relate the real life case studies and analyse them for acquiring the clarity on various aspects of entrepreneurship covered in the first 5 modules*	
	Contents: Case Studies of various start-ups (with Indian Context): Start-ups from Tech, Edtech, Fintech, and Agriculture domain; Study of successful start-ups and failed start-ups.	
	Learning Outcome: • *To evaluate the real-world examples and case studies that will help them understand the practical aspects of idea to product, fundraising and financial management in the context of entrepreneurship.*	
7	***Course Conclusion***	1

In-semester Assessment - Continuous Assessment: Suggested

1 Teams of 3-4 students shall present a One-Minute business idea pitch– ideation phase-10 marks
2 Teams of 3-4 students shall present a Three-Minute Business Pitch –Validation phase-10 marks
3 Teams of 3-4 students shall present a Five-Minute Business Pitch for Funding- 15 marks
4 Teams of 3-4 students shall present analysis of one case study of successful or failed start-up- (15 Marks)

Course Outcome: Learner will be able to

CO1: State the concept of Entrepreneurship and Indian Start-up ecosystem
CO2: Identify the business ideas and to analyse the environment for potential business opportunity.
CO3: Identify the specific measures to design, test, and validate Minimum Viable Product.
CO4: State the key concepts, and strategies related to fundraising for entrepreneurial ventures.
CO4: Identify the legal and regulatory framework for entrepreneurs in Indian context.
CO5: Analyse and correlate the reasons for the success or the failure of entrepreneurial firms.

Text Books:

1. Poornima Charantimath, Entrepreneurship Development- Small Business Enterprise, Pearson
2. Education Robert D Hisrich, Michael P Peters, Dean A Shapherd, Entrepreneurship, The McGrawHill Company
3. Dr TN Chhabra, Entrepreneurship Development, Sun India Publications, New Delhi
4. Vasant Desai, Entrepreneurial Development and Management, Himalaya Publishing House
5. Maddhurima Lall, Shikah Sahai, Entrepreneurship, Excel Books

6. Rashmi Bansal, STAY hungry STAY foolish, CIIE, IIM Ahmedabad
7. Law and Practice relating to Micro, Small and Medium enterprises, Taxmann Publication Ltd.

Reference Books:

1. Zero to One: Notes on Startups, or How the Build the Future by Peter Thiel
2. The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses by Eric Ries
3. India as Global Start-up Hub: Mission with Passion by C B Rao
4. Innovation and Entrepreneurship: Practice and Principles by Peter F Drucker
5. Effective Entrepreneurial Management: Strategy, Planning, Risk Management, and Organization - Robert D. Hisrich, Veland Ramadani, Springer (2017)
6. Entrepreneurship- Theory, Process Practice –by Kuratko &Hodgetts, Thompson South-Western Publication

Relevant Websites:

1. www.msme.gov.in
2. www.dcmesme.gov.in
3. www.msmetraining.gov.in

Other Resources:

1. NPTEL Course: Entrepreneurship By Prof. C Bhaktavatsala Rao, IIT Madrao
   Weblink https://onlinecourses.nptel.ac.in/noc20_mg35/preview
2. NPTEL Course: Entrepreneurship Essentials By Prof. Manoj Kumar Mondal, IIT Kharagpur
   Weblink https://onlinecourses.nptel.ac.in/noc21_ge06/preview

Course Type	Course Code	Course Name	Credits
PCC	ECPCC611	DISCRETE TIME SIGNAL PROCESSING	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. ECPCC509 Signals and Systems

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design / Development of Solutions
4. PO5 : Engineering Tool Usage
5. PO6 : Engineer and World
6. PO11: Life long Learning

Course Objectives:

1. To develop a thorough understanding of discrete Fourier transform and its use in spectral analysis and frequency domain filter designing.
2. To guide the students to design and realize IIR filters and FIR filters, gain an appreciation for the trade-offs necessary in the filter design and to evaluate the effects of finite word lengths on the filters.
3. To introduce the need and concept of multirate signal signal processing and its applications

Module	Details	Hrs.
	Course Introduction : Block diagram of Digital Signal Processing System, Advantages of signal processing in digital domain Discrete-Time Signal Processing (DSP) is at the core of modern technological systems where digital signal manipulation is essential. From telecommunications and control systems to biomedical devices and multimedia, DSP enables the efficient analysis and transformation of signals. This course explores critical DSP techniques, including the Discrete Fourier Transform (DFT) and its fast implementation using the Fast Fourier Transform (FFT), essential for spectral analysis and filtering in real-time applications. Students will delve into digital filter design, realization structures, and the challenges posed by finite word length effects, which impact precision in hardware implementations. The course also covers multirate signal processing, essential for efficient data compression and system performance optimization in advanced communication and signal processing systems. Through rigorous analysis and practical exercises, students	**01**

	will gain the skills necessary to design and implement sophisticated DSP algorithms in real-world scenarios.	
01.	**Discrete Fourier Transform** ***Learning Objective:*** 1. *To introduce the concept and applications of circular convolution and relate it to linear convolution* 2. *To educate the students about the need, mathematical formulation and efficient implementation of DFT in spectral Analysis of signals* **Contents:** Definition and Properties of DFT, IDFT, Circular convolution of sequences using DFT and IDFT. Filtering of long data sequences: Overlap-Save and Overlap-Add Method for computation of DFT. Fast Fourier Transforms (FFT), Radix-2 decimation in time and decimation in frequency FFT algorithms, inverse FFT ***Self-Learning Topics:*** *Goertzel Algorithm, Chirp-Z Algorithm, Split Radix FFT* ***Learning Outcomes:*** *A learner will be able to* *LO 1.1: Apply the properties of DFT to efficiently represent the given signal in the frequency domain (PI 1.1.2)* *LO 1.2 : Perform linear filtering of long data sequences using DFT (PI 1.4.1)*	**7-9**
02.	**IIR Digital Filters** ***Learning Objective:*** 1. *To introduce the concept of analog and digital frequencies along with their mapping.* 2. *To guide the students to transform the given data into design specifications and design appropriate IIR filter.* **Contents:** Analog and Digital filter specification, Frequency normalization Mapping from s-plane to the z-plane - impulse invariant and bilinear transformation, Design of IIR digital filters (Butterworth and Chebyshev-I) from analog filters using impulse invariant and bilinear transformation techniques, Analog and digital frequency transformations ***Self-Learning Topics: --*** ***Learning Outcomes:*** *A learner will be able to* *LO 2.1: Apply mathematical techniques for mapping the analog transfer function to digital domain. (PI. 2.4.1)* *LO 2.2 Identify system variables for designing an appropriate filter for the given specifications (PI 2.1.2)* *LO 2.3 Extract specifications of the digital filter from the given data and design an IIR appropriate filter for given real world signal. (PI 3.1.6) (PI 6.1.1)* *LO 2.4 Identify relevant data from the given resources and implement the proposed solution for given case study using appropriate tools (PI 3.3.3), (PI 5.2.2)*	6-8

03.	FIR Digital Filters ***Learning Objectives:*** 1. *To introduce the concept and significance of linear phase in digital filters* 2. *To educate the students about types and design of linear phase FIR filters* 3. *To guide the students to design FIR filters using windowing method and compare the performance for different types of windows*	
	Contents: Characteristics of linear phase FIR digital filters, Symmetric and antisymmetric FIR filter, Location of the zeros of linear phase FIR filters, Design of FIR filters using Window techniques (Rectangular, Hamming, Hanning, Blackmann, Bartlett), Comparison of IIR and FIR filters	**5-7**
	Self-Learning Topics: *Kaiser Window, Hilbert Transform, Frequency Sampling method, Optimum Equiripple filter design.*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Analyze the frequency domain behavior of Linear phase FIR filters (PI 2.1.3)* *LO 3.2 : Design Linear Phase FIR filters for the given constraints (PI 3.1.6)* *LO 3.3: Apply Windowing concepts for obtaining optimal design solution for the given specification pertaining to a real world scenario.(PI 3.3.3) (PI 6.1.1)* *LO 3.4: Identify relevant data from the given resources and implement the proposed solution for given case study using modern tool (PI 3.3.3), (PI 5.2.2)(PI 11.1.3)*	
04.	**Digital Filter Structures** ***Learning Objectives:*** ***1.*** *To educate the students about different Realization of digital filters and gain an appreciation for the tradeoffs necessary in the filter design.*	
	Realization structures for FIR systems: Cascade form, Lattice structure, Realization structures for IIR systems: Cascade form and parallel form structures, Lattice Ladder structure, Computational complexities for N order filter.	
	Self-Learning Topics: *Frequency Sampling structure*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Implementation of the designed filter using suitable Realization techniques (PI 2.3.2)* *LO 4.2 : Evaluate the impact of realization structure on computational complexity and hardware implementation (PI 2.4.4)*	
05.	**Finite Word Length Effects in Digital Filters** ***Learning Objective/s:*** 1. *To introduce the different sources of error in a digital signal processing system.* 2. *To educate the students about the effects of hardware limitation on the efficiency and stability of the designed filter.*	**5-7**

	Contents: Rounding and truncation errors, Quantization error, Effect of Product quantization on pole / zero locations, Noise model for direct form and cascaded IIR structure (first order) and zero input limit cycle.	
	Self-Learning Topics: --	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Identify and describe the sources of error in a digital signal processing system (PI 2.4.3)* *LO 5.2: Model quantization error and analyse its impact on the system performance. (PI 2.3.2)*	
06.	**Basics of Multirate Signal Processing**	**7-9**
	Learning Objective/s: 1. *To explain the difficulties associated fixed sampling rate systems and hence emphasize on the need of multirate systems.* 2. *To introduce the students to concept of decimation and interpolation and their relevance in filter banks*	
	Contents: Decimation by a factor D, interpolation by I, sampling rate conversion by a rational factor I/D Polyphase filter structures for decimation and interpolation filters, Design of Multistage implementation of sampling rate conversion (using elliptical filters) Two band filter bank	
	Self-Learning Topics: *Dyadic wavelet filter banks*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Analyse decimators and interpolators in the context of multirate system and filter banks.(PI 2.4.2), (PI 2.4.4)* *LO 6.2: Design Multirate systems for given sampling rate conversion factor using filter design techniques. (PI 3.1.6)* *LO 6.3: Efficiently model the given system using Polyphase structure. (PI 3.2.1)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.2	Apply mathematical transforms to solve problems.
1.4.1	Apply concepts of electronics and communication engineering and allied disciplines to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem.
2.3.2	Identify assumptions (mathematical and physical) necessary to allow modeling of a system at the level of accuracy required.
2.4.1	Apply engineering mathematics and computations to solve mathematical models
2.4.2	Produce and validate results through skilful use of contemporary engineering techniques.
2.4.3	Identify sources of error in the solution process, and limitations of the solution.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis
3.1.6	Determine design objectives, functional requirements and arrive at specifications
3.2.1	Apply formal idea generation tools to build models/prototypes in order to develop multiple engineering design solutions.
3.3.3	Identify relevant data from the given resources and arrive at an optimal design solution for particular specifications.
5.2.2	Demonstrate proficiency in using discipline-specific tools.
6.1.1	Identify environmental and health issues related to engineering profession with the help of relevant viewpoints from stakeholders and propose solutions.

Course Outcomes: A learner will be able to -

1. Analyze signals and systems using Discrete Fourier transform and employ DFT for linear filtering of long data sequences. *(LO 1.1, LO 1.2)*
2. Design and realize Butterworth, Chebyshev IIR filters and other frequency selective filters to satisfy the given specifications. .*(LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 4.1, LO 4.2)*
3. Characterize, design, and implement FIR filters while analysing their frequency response and performance.*(LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 4.1, LO 4.2)*
4. Analyze the effect of hardware limitations on performance of digital filters.*(LO 5.1, LO 5.2)*
5. Design and efficiently implement Multirate digital filters for the given specification. *(LO 6.1, LO 6.2, LO 6.3)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ECPCC611.1	3										
ECPCC611.2		3	3		2	2					2
ECPCC611.3		3	3		2	2					2
ECPCC611.4		3									
ECPCC611.5		3	3								
Average	3	3	3		2	2					

Text Books :

1. Proakis J., Manolakis D., "Digital Signal Processing", 4th Edition, Pearson Education.
2. Emmanuel C. Ifeachor, Barrie W. Jervis," Digital Signal Processing", A Practical Approach", Pearson Education
3. A Nagoor Kani "Digital Signal Processing", 2nd Edition. Tata Mc Graw Hill Education Private Limited

Reference Books :

1. Sanjit K. Mitra, "Digital Signal Processing – A Computer Based Approach", 4th Edition McGraw Hill Education (India) Private Limited.
2. Oppenheim A., Schafer R., Buck J., "Discrete Time Signal Processing", 2nd Edition, Pearson Education
3. S Salivahan, C Gnanapriya, "Digital Signal Processing", Mc Graw Hill Education (India) limited.
4. L. R. Rabiner and B. Gold, "Theory and Applications of Digital Signal Processing", Prentice-Hall of India, 2006.
5. Monson H Hayes, "Digital Signal Processing",Schaum's Outline Series, Mc Graw Hill Limited.

Other Resources :

1. Course: Digital Signal Processing By Prof. S.C Dutta Roy, IIT Delhi
   http://www.nptelvideos.in/2012/12/digital-signal-processing.html
2. Course: Digital Signal Processing By Prof. V. M. Gadre , IIT Bombay
   https://nptel.ac.in/courses/108/101/108101174/
3. Course: Digital Signal Processing By Prof. T. K. Basu , IIT Kharagpur
   https://nptel.ac.in/courses/108/105/108105055/

A. IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment-Theory (20 Marks)

Suggested breakup of distribution

a) Class test: 05 Marks
b) Design Assignment: 05 Marks
c) Case study: Design and Software Implementation, Analysis: 05 Marks
d) Regularity and active participation: 05 Marks

2. Mid Semester Examination (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

B. END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20% to 30% weightage, and the syllabus covered from MSE to ESE carrying 70% to 80% weightage

Course Type	Course Code	Course Name	Credits
PEC	ECPEC6021	RANDOM SIGNAL ANALYSIS	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. ECPCC405 - Engineering Mathematics-IV
2. ECPCC509 - Signals and Systems

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO3: Design / Development of Solutions
4. PO5: Engineering Tool Uses
5. PO11: Life-long learning

Course Objectives:

1. To impart a thorough understanding of fundamental principles of probability and conditional probability, and guide students in applying Bayes' theorem to various contexts such as communication systems and medical test evaluations.

2. Teach students to comprehend and compute probability density functions (pdf), cumulative distribution functions (CDF), and probability mass functions (PMF), and explore various distributions including Poisson, uniform, Gaussian, and Rayleigh distributions to solve engineering problems.

3. To explain the concepts of bivariate random variables and their joint distributions, teach students how to compute joint pdfs and PMFs, and guide them in analyzing conditional distributions, covariance, and correlation coefficients.

4. To help students solve problems involving the transformation of random variables, and teach them how to compute mean, variance, moments, and characteristic functions of transformed variables, emphasizing their significance in practical applications.

5. To guide students in analyzing the temporal and spectral characteristics of random processes, including stationary processes, Poisson and Gaussian processes, and the relationship between power spectral density and autocorrelation functions.

6. To impart an understanding of the principles of maximum likelihood estimation, logistic regression, Gaussian Mixture Models, and the Expectation-Maximization algorithm and applications of Bayes' theorem, MAP estimation, and the Naïve Bayes classifier to machine learning problems.

7. To assign case studies/simulations/projects that shall explicitly link key RSA topics to their relevance in Signal Processing/Telecommunication/AIDL.

Module	Details	Hours
	Course Introduction The Random Signal Analysis (RSA) course is crucial for students in electronics and telecommunication engineering, offering essential tools to analyze and interpret random processes in practical applications. It provides a solid grounding in probability theory, random variables, and random processes, enabling students to tackle uncertainties in communication systems and signal processing effectively. This knowledge is directly applicable in fields like machine learning, where understanding and modelling randomness is key to developing robust algorithms and systems. By mastering RSA concepts, students can enhance the reliability and performance of modern telecommunication networks and contribute to advancements in machine learning applications, making them well-prepared for both academic and industry challenges.	**01**
01.	**Probability Theory** ***Learning Objective/s:*** *1. Teach the concept of random signals, uncertainty and its implications in engineering and machine learning.* *2. Instruct students on the mathematical models with probability and random processes.* *3. Educate students on Bayes' theorem and guide them in applying it to various contexts such as binary communication channels, medical test evaluations, etc.* **Contents:** 1.1 Random signals and uncertainty - Uncertainty in day-to-day life, in engineering, and in machine learning. 1.2 Mathematical models – Modelling with probability, with random variables, and with random processes. 1.3 Bayes' theorem and its application in binary communication channels, in the evaluation of medical tests, etc. ***Self-Learning Topics:*** *1. To assign relevant class assignments as a part of continuous assessment.* *2. Engineering Application: Optical Communication System (Refer to Section 2.8 from the Miller and Childers reference book at serial number 1 below).* ***Learning Outcomes:*** *A learner will be able to* *LO1.1 Identify constraints of uncertainty in day-to-day life, engineering, and machine learning. (PI: 2.1.1)* *LO1.2 Apply mathematical modelling in probability and Bayes' theorem to solve problems related to binary communication channels, medical test evaluations, etc. (PI: 1.1.3)*	**06-08**
02.	**Random Variables** ***Learning Objective/s:*** *1. Teach the concepts of a histogram for given data samples and its relation with probability density function (pdf), cumulative distribution function (CDF), and probability mass function (PMF).*	**06-08**

	2. Educate students on various probability distributions and conditional distributions, their simulation, and their statistical parameters for Poisson, uniform, Gaussian, and Rayleigh distributions, and explain the concept of the central limit theorem.	
	Contents:	
	2.1 Histogram of given random data samples, probability density function (pdf), cumulative distribution function (CDF), and probability mass function (PMF). 2.2 Examples and simulation of Poisson distribution, uniform distribution, Gaussian distribution and central limit theorem, and Rayleigh distribution for specific applications; Their statistical parameters (mean and variance). 2.3 Conditional distributions.	
	Self-Learning Topics:	
	1. To assign relevant case studies/simulations/projects as a part of continuous assessment. *2. Engineering Application: Reliability and failure rates (Refer to Section 3.6 from the Miller and Childers reference book at serial number 1 below).*	
	Learning Outcomes :	
	A learner will be able to *LO2.1 Formulate mathematical models for random variables and analyze histograms, probability density functions (pdf), cumulative distribution functions (CDF), and probability mass functions (PMF) to understand random data samples. (PI: 2.3.1)* *LO2.2 Solve numerical related to mean, variance, and conditional distributions of various probability distributions such as Poisson, uniform, Gaussian, and Rayleigh distributions. (PI: 2.4.1)* *LO2.3 Identify suitable modern tools and simulate the above distributions for specific applications. (PI: 5.1.1)*	
03.	**Multiple Random Variables**	**07-09**
	Learning Objective/s:	
	1. Teach the concepts of bivariate random variables and their joint CDF, pdf, and PMF, conditional means and conditional variances, conditional distributions, covariance, and correlation coefficients.	
	Contents: 3.1 Bivariate random variables (BRVs) - Joint distribution functions, joint pdf, joint PMF and corresponding marginal probability functions; Independent BRVs. 3.2 Conditional distributions, covariance, and correlation coefficient. 3.3 Conditional means and conditional variances.	
	Self-Learning Topics:	
	1. To assign relevant class assignments as a part of continuous assessment *2. Engineering Application: Refer to the University of Texas document on 'Random Variables and Applications' available at: https://www.utdallas.edu/~scniu/OPRE-6301/documents/Random_Variables_Applications.pdf*	
	Learning Outcomes :	
	A learner will be able to *LO3.1 Apply the concepts of bivariate random variables, joint distribution functions, joint probability density functions (pdf), and joint probability mass functions (PMF) to solve relevant numerical. (PI: 1.1.1)* *LO3.2 Calculate conditional distributions, covariance, and correlation coefficients to*	

	analyze relationships between multiple random variables. (PI: 1.1.1)	
04.	**Functions of Random Variables**	**05-07**
	Learning Objective/s:	
	1. Teach the basic concepts of functions of random variables and their significance, Moment Generating Function (MGF) and characteristic function, and solve relevant numerical problems.	
	Contents:	
	4.1 Introduction to functions of random variables; Solving problems of the type $Y = g(X)$ and $Z=g(X, Y)$ (e.g., $\boldsymbol{Y = aX + b, Y = X^2, Z = X + Y, Z = XY, Z = X/Y}$ etc.), and transformation of two input RVs to two output RVs. 4.3 MGF and characteristic functions.	
	Self-Learning Topics:	
	1. To assign relevant class assignments as a part of continuous assessment *2. Engineering Application*: *Refer to the Indiana University document on Functions of RVs: https://pdesign.sitehost.iu.edu/me360/ch5.pdf.*	
	Learning Outcomes:	
	A learner will be able to *LO4.1 Apply mathematical techniques to solve problems involving functions of random variables. (PI: 1.1.1)* *LO4.2 Solve numerical related to MGF and characteristic functions. (PI: 2.4.1)*	
05.	**Random Processes**	**06-08**
	Learning Objective/s:	
	1. Teach the temporal characteristics of random processes and the concepts of stationary processes (Strict Sense Stationary (SSS) and Wide Sense Stationary (WSS), time averages, and ergodicity. *2. Educate students on the Poisson process and the Gaussian process.* *3. Explain the spectral characteristics of random processes, including the relationship between power spectral density (PSD) and autocorrelation function (ACF), white noise, and transmission through LTI systems.*	
	Contents:	
	5.1 Temporal Characteristics: Classification of random processes, joint density function, mean and autocorrelation, SSS, WSS, time averages and ergodicity, Poisson process, Gaussian process. 5.2 Spectral Characteristics: Relation between PSD and ACF, white noise, transmission of WSS through the LTI system.	
	Self-Learning Topics:	
	1. To assign relevant case studies/class assignments as a part of continuous assessment *2. Applications of Random Processes.* *(i) https://www.linkedin.com/pulse/applications-random-process-electronic-communication-geetha-muthu* *(ii) https://www.techniques-ingenieur.fr/en/resources/article/ti383/random-processes-foundations-and-applications-te5222/v1*	
	Learning Outcomes:	

	A learner will be able to *LO5.1 Classify given random processes into WSS/SSS/Ergodic. (PI: 2.4.1)* *LO5.2 Evaluate the spectral characteristics of transmission of the WSS process through the LTI system. (PI: 2.3.1)*	
06.	**Maximum Likelihood and Bayesian Probability**	**07-09**
	Learning Objective/s: 1. *Teach the principles of maximum likelihood estimation and its applications in machine learning, and logistic regression as an example of maximum likelihood estimation.* 2. *Instruct students on the Gaussian Mixture Model (GMM) and the Expectation-Maximization (EM) algorithm, Bayes' theorem and its applications in machine learning, including Maximum A Posteriori (MAP) estimation and the Naïve Bayes classifier.* 3. *Make the students identify problems relevant to the above-stated learning objectives through self-directed learning.*	
	Contents: 6.1 Maximum likelihood estimation, relationship to machine learning, logistic regression as maximum likelihood, GMM and EM algorithm and their relevance in solving practical problems. 6.2 Bayes' theorem, MAP, and machine learning, Naïve Bayes classifier and their relevance in solving practical problems.	
	Self-Learning Topics: 1. *To assign relevant case studies/simulations/projects as a part of continuous assessment* 2. *https://www.datasciencecentral.com/understanding-the-applications-of-probability-in-machine-learning/* 3. *https://www.tableau.com/learn/articles/machine-learning-examples* 4. *https://www.cs.toronto.edu/~urtasun/courses/CSC411_Fall16/tutorial1.pdf* 5. *https://ieeexplore.ieee.org/iel7/79/9127839/09127856.pdf*	
	Learning Outcomes: *A learner will be able to* *LO6.1 Apply maximum likelihood estimation to model parameters in engineering problems. (PI: 2.4.1)* *LO6.2 Utilize Bayesian probability theory to make informed decisions in engineering applications, integrating concepts of MAP and Naïve Bayes classifiers for problem-solving. (PI: 1.1.3)* *LO6.3 Critically evaluate current research trends in machine learning applications of maximum likelihood and Bayesian methods, demonstrating the ability to access and synthesize information from technical literature. (PI: 11.3.1)(PI: 3.1.1)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.1	Apply mathematical techniques such as calculus, linear algebra, probability and statistics, and Boolean algebra to solve problems.

1.1.3 Apply advanced mathematical techniques of electronics and telecommunication or computer and information science to describe/solve/construct a mathematical model of a system.

2.1.1 Articulate problem statements and identify primary objectives and key constraints.

2.3.1 Combine scientific principles and engineering concepts to formulate a model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.

2.4.1 Apply engineering mathematics and computations to solve mathematical models.

3.1.1 Recognize that need analysis is key to good problem definition.

5.1.1 Identify modern hardware and software engineering tools, techniques and resources for engineering activities.

11.3.1 Identify sources and comprehend information from technical literature and other credible sources of information.

Course Outcomes:

Students will be able to

1. Apply fundamental principles of probability theory and advanced mathematics to model, solve, analyse, and simulate problems related to uncertainty, Bayes' theorem, random variables, multiple random variables, and functions of random variables. (*LO1.1, LO1.2, LO2.2, LO2.3, LO3.1, LO3.2, and LO4.1*)

2. Analyze and simulate uncertainty in mathematical modelling of random variables, histograms of density functions, moment-generating functions, and characteristic functions. (*LO2.1, LO2.3, and LO4.2*)

3. Analyze the mathematical models of systems representing temporal and spectral characteristics of random processes, and apply this understanding to solve the problems. *(LO5.1 and LO5.2)*

4. Apply fundamental principles of probability theory and advanced mathematics to solve and analyse problems related to machine learning algorithms. (*LO6.1 and LO6.2*)

5. Identify relevant problems in modelling machine learning applications and present appropriate solutions by applying maximum likelihood and Bayesian methods. (*LO6.1, LO6.2, and LO6.3*)

CO-PO Mapping Table with Correlation Level:

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ECPEC6021.1	3	3	-	-	2	-	-	-	-	-	-
ECPEC6021.2	3	3	-	-	2	-	-	-	-	-	-
ECPEC6021.3	3	3	-	-	-	-	-	-	-	-	-
ECPEC6021.4	3	3	-	-	-	-	-	-	-	-	-
ECPEC6021.5	3	3	3	-	-	-	-	-	-	-	2
Average	3	3	3	-	2	-	-	-	-	-	2

Text Books:

1. A. Papoulis and S. U. Pillai, *Probability, Random Variables, and Stochastic Processes*. Tata McGraw Hill Education.
2. H. Stark and J. W. Woods, *Probability, Statistics, and Random Processes for Engineers*, 4th ed. Pearson Education, 2012.
3. P. R. Babu, *Probability Theory and Random Process*. Tata McGraw Hill Education.

4. T. Veerarajan, *Probability, Statistics and Random Process*, 3rd ed. Tata McGraw Hill Education, 2018.
5. J. Brownlee, *Probability for Machine Learning*, (e-Book). Copyright 2020 Jason Brownlee.

Reference Books:

1. S. Miller and D. Childers, *Probability and Random Processes with Applications to Signal Processing and Communications*. Elsevier (2004).
2. H. Hsu, Theory and Problems of Probability, Random Variables, and Random Processes, Schaum's Outline Series. McGraw Hill, 1997.
3. A. L. Garcia, *Probability and Random Processes for Electrical Engineering*, 2nd ed. Pearson Education.
4. R. E. Walpole et al., Probability and Statistics for Engineers and Scientists, 8th ed. Pearson Education.
5. D. Witten, T. Hastie, and R. Tibshirani, An Introduction to Statistical Learning, 7th ed. Springer, 2017.
6. P. Kousalya, *Probability, Statistics, and Random Processes*. Pearson Education.
7. D. C. Montgomery, E. A. Peck, and G. G. Vining, *Introduction to Linear Regression Analysis*, student ed. Wiley.

Other Resources :

1. Introduction to probability and Statistics, Prof. G. Srinivasan (IIT Madras); https://onlinecourses.nptel.ac.in/noc21_ma01/preview
2. Probability and Probability Distributions By Dr. P.Nagesh: https://onlinecourses.swayam2.ac.in/cec21_ma02/preview
3. Khan Academy - Statistics and Probability: https://www.khanacademy.org/math/statistics-probability/random-variables-stats-library
4. MIT OpenCourseWare: https://ocw.mit.edu/courses/6-011-signals-systems-and-inference-spring-2018/pages/lecture-slides/

A. IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment-Theory (20 Marks)

Suggested breakup of distribution

a) Case studies and/or Simulations and/or Projects and/or Class Assignments which will map the concepts in this course to AIML: 10 Marks

c) Flip classroom: 05 Marks

d) Regularity and active participation: 05 Marks

2. Mid Semester Examination (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

B. END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20% to 30% weightage, and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Type	Course Code	Course Name	Credits
PEC	ECPEC6022	OPTICAL FIBER COMMUNICATION	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. ECPCC407 Principles of Communication
2. ECPCC510 Digital Communication
3. BSC102 Engineering Physics-I

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO 3: Design/Development of Solution
4. PO5: Modern tool usage
5. PO 8: Individual and teamwork
6. PO 9: Communication
7. PO 11: Life-long learning

Course Objectives:

1. To familiarize with basic concepts and theory to understand signal propagation through optical fiber.
2. To convey the channel impairments like losses and dispersion, and determine transmission losses in optical fiber.
3. To convey different modulation techniques.
4. To explain link budget using given data.
5. To develop an understanding related to different optical parameter measurements techniques.
6. To familiarize with different optical networks and its management.

Module	Details	Hrs.
	Course Introduction Optical communication is a technology that uses light to transmit information over distances. This course will help students to learn historical development of optical communication. This course will help students to learn basic of optical communication, working of sources and detectors, different components and optical networks.	**01**

	As technology evolves, there's a growing need for efficient communication systems with fast and reliable data transmission. Knowledge of optical communication is crucial for designing and implementing the infrastructure needed for high-speed internet and telecommunications. The telecommunications and networking sectors require skilled professionals in optical communication, providing ample career opportunities.	
01.	**Introduction to optical fibers communication** ***Learning Objective:*** ***1.*** *Familiarize students with need for optical fiber communication* ***2.*** *Convey basics related to optical fiber communication* ***3.*** *Describe MCVD technique for high quality fiber* ***4.*** *Convey basics of Photonic Crystal Fiber*	**07**
	Contents: Optical Bands and Windows, Need for optical fiber communication, Fiber optic cable types and color codes, advantages and disadvantages of optical fiber cables, Applications Basics of Optical Fiber: Review of Ray theory, Light propagation in optical fiber Classification of optical fibers based on number of propagating modes, refractive index profile, fiber material used, Propagation modes Concept of mode field diameter in single mode fiber Fiber material, Fabrication techniques for high quality fiber: Modified Chemical Vapor Deposition method Fiber joints, fiber connectors, splices. Brief introduction to Photonic Crystal Fiber and its types.	
	Self-Learning Topics: Mechanical properties of fiber	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply concepts of optical communication such as number of modes, RI profile, material used for fabrication and color code to classify fibers. (PI.1.4.1)* *LO 1.2: Identify the types of fiber which suits to requirement of particular application. (PI.2.1.2)* *LO 1.3: Breakdown MCVD fabrication technique into interconnected sub systems and analyze the working of it. (PI. 2.2.1)* *LO 1.4: Identify the method / component such as fiber joint, fiber connector, splice which can be used for joining fibers depending on the requirement of optical fiber communication system. (PI. 2.1.3)* *LO 1.5: Summarize photonic crystal fibers which are used in optical fiber communication system to transmit high optical power. (PI 1.3.1)* *LO 1.6: Determine transmission parameters for optical fiber using Ray theory and arrive at specifications. (PI. 3.1.6)* *LO 1.7: Identify given data such as numerical aperture, critical angle, acceptance angle and arrive at best propagation mode for a given signal.(PI 3.3.3)*	
02.	**Transmission Characteristic of Optical Fiber**	**07**

	Learning Objective: 1. *Develop understanding of dispersion in Optical fiber through basic concepts.* 2. *Familiarize students with different transmission losses in the optical fiber communication.* 3. *Convey concept of attenuation in Optical fiber.*	
	Contents: Signal degradation in optical fibers: Attenuation, Absorption losses- Intrinsic and Extrinsic absorption, Scattering losses- Linear and nonlinear scattering losses, Bending losses Signal distortion in fiber: Dispersion-Intermodal and Intramodal Dispersion, Need for dispersion management, Dispersion compensation techniques Specialty Fibers: Erbium doped fiber, Photosensitive Sensitive fiber, Bend-insensitive fiber, Polarization preserving fiber	
	Self-Learning Topics: Polarization, Solitons	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply concepts of attenuation, dispersion etc. to determine their value. (PI 1.4.1)* *LO 2.2: Identify the type of dispersion and apply relevant knowledge to solve a given problem. (PI. 2.1.2)* *LO 2.3: Apply fundamental concepts to estimate losses in fiber. (PI 1.3.1)* *LO 2.4: Identify appropriate method for reducing effect of dispersion in optical fiber system. (2.2.3)* *LO 2.5: Apply concepts of optical fiber communication to summarize different types of specialty fibers. (PI 1.4.1)* *LO 2.6: Develop ability to learn independently through hands-on activity based on parameters measurement, analysis of losses and present result effectively. (PI 1.3.1, PI 8.1.1, PI. 8.2.1, PI. 9.1.1, PI 9.2.1, PI. 11.1.2, PI. 11.1.3)*	
03.	**Optical Communication Sources and detectors, and Modulation techniques**	**08**
	Learning Objective: ***1.*** *Develop understanding related to working principle and characteristics of sources and detectors* *2. Familiarize students with different modulation schemes in the optical fiber communication.*	
	Contents: Block diagram of optical fiber communication system Optical Sources- LED: Edge emitter led LASER- Vertical cavity surface emitting laser Optical detectors: Photodetector, p-i-n photodiode, Avalanche photodiode Concept of Quantum efficiency, Responsivity	

	Modulation schemes used in optical communication- On Off Keying, Phase shift keying	
	Self-Learning Topics: ***Double hetrojunction Led, Surface emitter led, Distributed feedback laser***	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Breakdown the entire optical fiber communication system into interconnected sub systems and analyze the working of it. (PI. 2.2.1)* *LO 3.2: Compare different sources as well as detectors used in optical fiber communication with their working principle and characteristics to select the best according to requirement. (PI. 2.2.4)* *LO 3.3: Determine different parameters such as efficiency, responsivity related to optical sources/detectors and arrive at specifications. (PI. 3.1.6)* *LO 3.4: Identify parameters applicable to different modulation schemes used in optical communication and also differentiate these techniques by applying respective knowledge. (PI 2.1.2)* *LO 3.5: Identify the given data such as frequency, bit rate and arrive at best modulation scheme for a given condition.(PI 3.3.3).*	
04.	**Optical amplifier and receiver** ***Learning Objectives:*** 1. *Familiarize students with different types of optical amplifiers with their working principle* *2. Convey working of optical receivers.* *3. Summarize concept of Bit error rate, Q function.* *4. Understand a link budget.*	**08**
	Contents: Optical amplifier- Erbium doped fiber amplifier, Raman amplifier, Semiconductor optical amplifier Noise figure and signal to noise ratio in optical amplifier Optical receivers: Block diagram, types of noise in receiver Receiver performance parameters: Bit error rate, Q function Coherent detection, Intensity modulation Point to point links system considerations, link power budget, and rise time budget	
	Self-Learning Topics: Wideband Optical amplifier	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply concepts of amplification to summarize working of optical amplifiers with principle. (PI. 1.4.1).* *LO 4.2: Breakdown the entire optical fiber communication system into interconnected sub systems to determine losses or delay incorporated by each block and illustrate the entire link budget. (PI. 2.2.1)* *LO 4.3: Apply concepts of coherence and direct detection to determine signal parameters through mathematical analysis. (PI 2.1.2)* *LO 4.4: Develop ability to learn independently through hands-on activity based on working of optical amplifier and present result effectively. (PI 1.3.1, PI 8.1.1, PI. 8.2.1, PI. 9.1.1, PI 9.2.1, PI. 11.1.2, PI. 11.1.3)*	

05.	**Performance measurement and monitoring** ***Learning Objective/s:*** *1. Understand a need to perform optical parameter measurement.* *2. Understand different optical parameter measurement procedure.* *3. List and understand different test equipments used in optical communication system.*	**06**
	Contents: Measurements: Optical power measurement, Attenuation measurement, Dispersion measurement, Eye diagram tests, Optical Signal to noise ratio monitoring Test equipments: Test support lasers, Optical spectrum analyzer, Visual fault indicator, Conformance analyzer, Optical Time Domain Reflectometer	
	Self-Learning Topics: Fiber refractive index profile measurement, Numerical aperture measurement	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Identify an appropriate test equipment for particular parameter measurement in optical communication system. (PI. 5.1.1)* *LO 5.2: Use an appropriate measurement method to measure particular parameter such as power, attenuation to solve a given problem. (PI. 5.1.2)* *LO 5.3: Develop ability to learn independently through hands-on activity based on parameters measurement and present result effectively. (PI 1.3.1, PI 1.4.1, PI 8.1.1, PI. 8.2.1, PI. 9.1.1, PI 9.2.1, PI. 11.1.2, PI. 11.1.3)*	
06.	**Optical Networks and management** ***Learning Objective/s:*** *1. Understand need of different optical network system components.* *2. Differentiate SONET and SDH techniques.* *3.List and understand different network management functions.*	**07**
	Contents: Components: Couplers, Isolators , Circulators, Fiber gratings filters, Add drop multiplexers, switches, Variable optical attenuator, Optical amplifier Network: SONET (Synchronous Optical Network) and SDH (Synchronous Digital Hierarchy) standards, Protection schemes in SONET/SDH Types of WDM (Wavelength Division Multiplexing) Networks WDM Long Haul Networks Network management functions, configuration management, performance management, fault management	
	Self-Learning Topics: Data center networks and Elastic Networks, Optical Burst switching Networks, Software Defined Network	
	Learning Outcomes:	

	A learner will be able to *LO 6.1: Apply concepts of networking to summarize different optical network system components and different networks. (PI. 1.4.1)* *LO 6.2: Identify direction/s of signal propagation, number of modes, types of protection links to solve a given network problem. (PI. 2.1.2)* *LO 6.3: Compare different types of networks on the basis of bit rate, data transmission principle to select the appropriate transmission method/network. (PI 2.2.4)* *LO 6.4: Apply knowledge of network management functions to solve given problem. ((PI. 1.3.1)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply concepts of electronics and communication engineering and allied disciplines to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem.
2.2.1	Breakdown complex problem into interconnected sub systems and analyse by proper assumptions/ justification from information and resources.
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions
2.2.4	Compare and contrast alternative solutions to select the best methodology.
3.1.6	Determine design objectives, functional requirements and arrive at specifications
3.3.3	Identify relevant data from the given resources and arrive at a best fitting design solution for particular specifications.
5.1.1	Identify modern hardware and software engineering tools, techniques and resources for engineering activities.
5.1.2	Use/adapt/modify/create tools and techniques to solve engineering problems
8.1.1	Recognize a variety of working and learning preferences; appreciate the value of diversity on a team
8.2.1	Demonstrate effective communication, problem-solving, conflict resolution and leadership skills
9.1.1	Read, understand and interpret technical and/or non-technical information.
9.2.1	Listen to and comprehend information, instructions, and viewpoints of others.
11.1.2	Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to close this gap
11.1.3	Develop ability to learn independently through methods distinct from instructor provided materials.

Course Outcomes: A learner will be able to -

1. Apply basic concepts and theory to understand signal propagation through optical fiber. *(LO 1.1 to LO 1.7)*
2. Summarize the channel impairments like losses and dispersion, and determine transmission losses in optical fiber. *(LO 2.1 to LO 2.6)*
3. Classify the Optical sources as well as detectors with their working principle and characteristics, and analyse the working of receiver in optical communication system. *(LO 3.1 to 3.5)*

4. Design power and rise time budget for a given set of optical fiber system parameter. *(LO 4.1 to LO 4.4)*
5. Select an appropriate device for a particular parameter under measurement. *(LO 5.1 to LO 5.3)*
6. Comprehend different optical networks and its management. *(LO 6.1 to LO 6.4)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ECPE6022.1	3	3	3								
ECPE6022.2	3	3						3	3		3
ECPE6022.3		3	3								
ECPE6022.4	3	3	3					3	3		3
ECPE6022.5					3						
ECPE6022.6	3	3									
Average	3	3	3		3			3	3		3

Text Books :

1. John M. Senior Optical Fiber Communication, 3rd Edition, 2013
2. Gerd Keiser, Optical Fiber Communication, 4th Edition, 2012
3. T.L.Singhal Optical Fiber Communication Principles and Applications, Cambridge Press, Edition 2016

Reference Books :

1. G Agarwal Fiber optic communication Systems
2. Biswanath Mukherjee, ―Optical Communication Networks‖, McGraw-Hill, 1997
3. Rajiv Ramaswami and Kumar N. Sivarajan, ―Optical Networks: A Practical Perespective‖, Elsevier Publication Elsevier India Pvt.ltd, 3rd Edition, 2010
4. P.E.Green, ―Optical Networks‖, Prentice Hall,1994

Other Resources :

1. Fiber Optic Communication Technology- Deepa Venkitesh, Department of Electrical Engineering, IIT Madras
. **https://www.youtube.com/playlist?list=PLHj96QRJ0kOhH8xoXXrOgkMf9ZOvjhqYl**
2. Semiconductor Optoelectronics by Prof. M.R.Shenoy, Department of Physics, IIT Delhi **https://www.youtube.com/playlist?list=PLbMVogVj5nJSvhvgcBfT3e6HFFuhq2xqz**

IN-SEMESTER ASSESSMENT (75 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

1. Class test: 5 marks
2. Hands-on assignment: 10 marks
3. Regularity and active participation: 5 marks

2.Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
PEC	ECPEC6023	ANALOG VLSI	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. ESC 102 Basic Electrical Engineering
2. ESC 203 Basic Electronics
3. ECPCC302 Network Theory
4. ECPCC303 Electronics Devices and Circuits
5. ECPCC406 Linear Integrated Circuits
6. ECPEC5013 Digital VLSI

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design / Development of Solutions
4. PO5: Modern tool usage

Course Objectives:

1 To learn the basics of CMOS Analog design in the field of Electronics and Telecommunication.

2 To familiarise the methodologies for analysis and design of fundamental CMOS Analog circuits like Basic Building Blocks of Analog Design, Single stage Amplifiers, Analog Sub Circuits and Bandgap reference.

Module	Details	Hrs.
	Course Introduction This course is personalized to provide with a comprehensive essential principles and techniques involved in designing analog electronic circuits in an integrated circuit using MOS transistors which is foundational for modern electronic systems. As we delve into the details of analog design, we will gain valuable insights into the principles, methodologies, and tools that drive the creation of integrated circuits which is need of the hour.	**01**
01.	**Fundamentals Analog Building blocks** ***Learning Objective/s:***	

	1. *To familiarize the basics of MOS Transistor on the basis of small signal and large signal model.* **2.** *To provide competence in engineering fundamentals to recognize the concepts of basic building blocks and basic cells.*	
	Contents: Introduction to Analog VLSI Circuits Design, Design Flow of Analog VLSI Circuits. Second order effects, MOS small signal model, MOS capacitances, body bias effect, Current biasing, voltage biasing, technology biasing, relative comparison and limitations. Basic building blocks and basic cells – Switches, active resistors, current sources and sinks, Gilbert Cell. Passive and Active Current Mirrors – Basic Current Mirrors, Cascode Current Mirrors, Active Current Mirrors.	
	Self-Learning Topics:	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply fundamental engineering concepts to realize the second order effects, current source, sink and comparison of different biasing. (P.I.-1.3.1)* *LO 1.2: **Apply** body bias techniques to modify threshold voltages in a given scenario. (P.I.-1.4.1)* *LO 1.3: Identify and analyze the circuit implementation of each biasing methods (current, voltage and technology), compare and arrive to the limitations if any for a given problem. (P.I.-2.1.3)* *LO 1.4: Compare and contrast alternative solutions to select the best methodology on active and passive current mirrors. (P.I-2.2.4)*	
02.	**Analog CMOS Sub Circuits** ***Learning Objective:*** 1. *To provide proficiency of different switched capacitor circuits with the help of simulation software.*	
	Contents: Switched Capacitor circuits - basic principles, sampling switches, switched capacitor integrator, switched capacitor amplifier Simulation of CMOS sub circuits using SPICE.	
	Self-Learning Topics:	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply fundamental engineering concepits on clock phases, non-overlapping clocks, charge injection and clock feedthrough effects. (P.I-1.3.1)* *LO 2.2: Apply fundamental engineering concepts to solve Switched Capacitor circuits (P.I-1.4.1)* *LO 2.3: Compare switched capacitor circuits with traditional resistor-based designs in terms of performance and area. (P.I.- 2.2.4).* *LO 2.4: Identify the mathematical, engineering and other relevant knowledge that applies to switched capacitor integrator and amplifier circuits. (P.I-2.1.3)*	
03.	**CMOS Single Phase Amplifiers**	

	Learning Objective: ***1. To provide the ability to design & analyze MOS based Analog VLSI Circuits***	
	Analytical justification of operating region suitable for amplification/switching and limitations, design of Common-Source stage (with resistive load, diode connected load, current-source load, triode load, source degeneration), source follower, common-gate stage, cascode stage, folded cascode stage with parasitics. Frequency responses of CS stage, CD stage, CG stage, cascode stage, simulation of CMOS amplifiers using SPICE.	
	Self-Learning Topics:	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply fundamental engineering concepts to solve engineering problems on basic operating region suitable for particular application. (P.I-1.3.1).* *LO 3.2: Apply core principles to classify different CMOS amplifier topologies (P.I-1.4.1)* *LO 3.3: Identify the mathematical approach that applies to different CMOS amplifier topologies for a given specification. (P.I-2.1.3).* *LO3.4: Identify the sources of error in topologies, analyze with frequency responses and their limitations. (P.I-2.4.3)* *LO 3.5: Develop an ability to learn different CMOS amplifier topologies for given specification using open source software. (P.I.- 3.1.3,P.I-5.1.1)*	
04.	**Noise Characteristics** ***Learning Objectives:*** 1. *To provide the statistical characteristics of different types of noise* **2.** *To perform analysis and design using simulator/editors on noise in single stage amplifiers.*	
	Contents: Statistical characteristics of noise, Types of noise - thermal noise, flicker noise, Representation of noise in single-stage amplifiers (CS, CD and CG stages), noise bandwidth.	
	Self-Learning Topics:	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply the different statistical characteristics of Noise and its types in single stage amplifiers. (P.I.-1.3.1).* *LO 4.2: Compare and contrast between thermal noise and flicker noise in terms of their frequency behavior and circuit impact. (P.I-2.2.4)* *LO 4.3: Combine scientific principles in order to model and represent noise sources in single-stage amplifier configurations like Common Source (CS), Common Drain (CD), and Common Gate (CG) using equivalent noise circuits in terms of accuracy and applicability.(P.I-2.3.1)*	
05.	**Differential Amplifier and Operational Amplifier** ***Learning Objective/s:*** *1.To introduce the skills to design analog VLSI circuits for a given specification.*	
	Contents: Single-ended and differential operation, basic differential pair – qualitative and quantitative analysis, common-mode response, differential pair with MOS loads.	

	Performance parameters of op-amp, one stage op-amp, two-stage CMOS op-amp, Gain boosting, slew rate, power supply rejection, Simulation of differential amplifiers using SPICE. ***Self-Learning Topics:*** ***Learning Outcomes :*** *A learner will be able to* *LO 5.1: Apply the fundamental concepts of basic differential pair of operational-amplifier in single ended mode with resistive/ MOS loads to solve the common mode behavior of the circuit. (P.I.-1.3.1)* *LO 5.2: Identify relevant data from the given resources and arrive at an optimal design solution to design a differential amplifier using MOS loads and determine its gain, output swing, and input impedance for a particular application. (P.I-3.3.3)* *LO 5.3: Identify basic concepts of 2 stage amplifier and analyze all the basic performance metrics of analog VLSI design (CMRR, slew rate, voltage gain, differential gain, PSRR) for the given specifications. (P.I-2.1.3).* *LO 5.4: Develop an ability to model single/two- stage differential amplifier using open source tool and present it effectively. (P.I-1.4.1, P.I-2.3.1, P.I-3.1.6, PI 8.1.1, PI. 8.2.1, PI. 9.1.1, PI 9.2.1, PI 11.1.2, PI. 11.1.3)*	
06.	**Bandgap Reference** ***Learning Objective/s:*** 1. *To provide a knowledge of general purpose band gap reference .* **Contents:** General considerations, Supply independent biasing, temperature-independent references, negative-TC voltage, positive TC voltage, Bandgap reference, PTAT generation, curvature correction, Design of BGR under low voltage conditions ***Self-Learning Topics:*** ***Learning Outcomes:*** *A learner will be able to* *LO 6.1: Apply the need for supply-independent biasing, temperature independent biasing and its importance Bandgap reference design (P.I-1.3.1)* *LO 6.2: **Identify** PTAT generation mechanism and their integration with CTAT source to create a stable reference for a given problem. (P.I-2.1.3)* *LO 6.3: **Identify relevant data d**esign a basic bandgap reference circuit and calculate its output voltage for given process parameters. (P.I- 3.3.3,)* *LO 6.4: Develop an ability to design a low-voltage bandgap reference using sub-bandgap or current-mode architectures with performance optimization. (P.I-1.4.1, P.I-2.3.1, P.I-3.1.6, PI 8.1.1, PI. 8.2.1, PI. 9.1.1, PI 9.2.1, PI 11.1.2, PI. 11.1.3)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply concepts of electronics and communication engineering and allied disciplines to solve engineering problems.

2.1.3 Identify the mathematical, engineering and other relevant knowledge that applies to a given problem.
2.2.4 Compare and contrast alternative solutions to select the best methodology.
2.3.1 Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
2.4.3 Identify sources of error in the solution process, and limitations of the solution.
3.1.6 Determine design objectives, functional requirements and arrive at specifications
3.3.3 Identify relevant data from the given resources and arrive at a best fitting design solution for particular specifications.
5.1.1 Identify modern hardware and software engineering tools, techniques and resources for engineering activities.
8.1.1 Follow ethical practices to create a document.
8.2.1 Identify and apply moral and ethical principles of IEEE professional code of ethics.
9.1.1 Recognize a variety of working and learning preferences; appreciate the value of diversity on a team
9.2.1 Demonstrate effective communication, problem-solving, conflict resolution and leadership skills
11.1.2 Analyse different forms of financial statements to evaluate the financial status of an engineering project.
11.1.3 Identify credible estimates of the costs and benefits related to engineering project and recognize the uncertainties in the estimates due to implications of taxes and cost fluctuations on these values and comparisons.

Course Outcomes: A learner will be able to -

1. Identify, formulates, and solves engineering problems in the area of analog integrated circuits - MOS device physics, MOS models and design current mirror circuits. *(LO1.1, LO1.2, LO1.3, LO 1.4).*
2. To realise the basic concepts of switched Capacitor and analyse the circuits of switched capacitor integrator amplifier. *(LO 2.1, LO2.2, LO 2.3, LO 2.4)*
3. To apply, analyse and design single stage MOS amplifiers with noise.(*LO3.1,LO3.2, LO3.3,LO3.4,LO 3.5,LO4.1,LO4.2, LO4.3)*
4. Acquire the design principles of different categories of amplifiers like the single stage MOS amplifiers with noise, MOS differential amplifier, CMOS OPAMP .*(LO5.1,LO5.2,LO5.3,LO 5.4)*
5. Realize the concept of designing band gap reference circuits providing constant dc voltage and immune to temperature variations, noise, supply voltage fluctuations. *(LO 6.1, LO 6.2, LO 6.3, LO6.4)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ECPEC6023.1	3	3									
ECPEC6023.2	3	3									
ECPEC6023.3	3	3	2		2						
ECPEC6023.4	3	3	3		3			3	3		3
ECPEC6023.5	3	3	3		3			3	3		3
Average	3	3	3		3			3	3		3

Text Books :

1. B.Razavi , " Design of Analog CMOS Integrated Circuits" 1st Edition , Mc Graw Hill 2001.
2. Jacob Baker "CMOS Circuit Design- Layout and Simulation" (IEEE Press Series on Microelectronics Systems).
3. Gray, Meyer, Lewis and Harris, "Analysis and design of Analog Integrated Circuits", 4th Wiley International Edition
4. Sedra and Smith, Microelectronics Circuits, Oxford University Press, 2004
5. P.E Allen and D. R. Holberg, 'CMOS Circuit Design,Layout and Simulation", 2nd Edition Oxford University Press,2002.

Reference Books :

1. Harry W. Li. And David E. Boyce, "CMOS Circuit Design, Layout, Simulation, PHI Edition 2005.
2. D.A. Johns and K. Martin; Analog Integrated Circuit Design; John Wiley and Sons, 2004.
3. M. Ismail and Terri Fiez; Analog VLSI; McGraw Hill, 1994.

Other Resources :

1. NPTEL Course: Analog Circuits By Prof. Nagendra Krishnapura, IIT Madras :-Web link- Analog Circuits - Course
2. NPTEL Course: Analog Circuits By Prof. A. N Chandorkar, IIT Bombay :-Web link- Analog Circuits - Course
3. NPTEL Course: Analog Electronic Circuits By Prof. Pradip Mandal, IIT Bombay :-Web link- NOC:Analog Electronic Circuits

IN-SEMESTER ASSESSMENT (75 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

Numerical Assignment/s (min 20 problems) – 05 Marks

Class test based on above numerical assignment – 05 Marks

Activity based test(Simulation): 05 Marks

Regularity and active participation:05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
LBC	ECLC609	DISCRETE TIME SIGNAL PROCESSING LABORATORY	02

Examination Scheme		
Term Work	**Practical /Oral**	**Total**
25	25	50

Pre-requisite:

1. ECPCC509 : Signals and Systems
2. ECPCC611 : Discrete Time signal Processing
3. ECPCC510 : Digital Communication

Program Outcomes addressed:

1. PO2: Problem analysis
2. PO3 : Design/ Development of Solution
3. PO4: Conduct investigations of complex problems
4. PO5: Engineering tool usage
5. PO9: Individual and Collaborative team work

Course Objectives:

1. To impart the knowledge on various components of closed loop control systems.
2. To impart the knowledge on modelling and transient and steady state analysis of closed loop control systems.
3. To impart the knowledge on the analysis of control system using Root-locus and Bode-plot technique with simulation platform.

Module	Details	Hrs
	Course Introduction Introduction to Matlab: Reading , storing variables and arrays, ':' operator, loops Subplots, Plotting basic signals Array multiplications Frequency response	**01**
01.	**Signal Processing concepts** ***Learning Objective:*** *0. To teach the students to use modern programming languages to implement the signal processing concepts and techniques such as convolution, DF, correlation etc..*	**06-08**

	Experiment : a. Convolve this swept frequency response waveform with 1st order impulse responses $h1\ (n)$ = [0.5, 0.5] $and\ h2\ (n)$ = [0.5, -0.5] ; 6th order responses, test the results with two sine waves with frequencies $0.2\pi\ and\ 0.88\ pi$ b. Cross correlation: Radar Example ; Seismology example c. To determine impulse, magnitude, phase response and pole-zero plot of the transfer functions with single real pole, repeated real pole and complex poles for a=0.5, a=1 and a=2 (user input) *A learner will be able to* *LO 1.1: Apply and demonstrate the concepts of signal processing to real time signals (P 2.4.1) (PI 6.1.1)* d. DFT and effect of Zero padding e. To detect the signal frequencies buried in noise using DFT *A learner will be able to* *LO 1.2: Apply the properties of DFT to efficiently represent the given signal in the frequency domain (PI 1.1.2) (PI5.2.2)* *LO 1.3 : Perform linear filtering of long data sequences using DFT (PI 1.4.1)*	
	Self-Learning Topics: *Goertzel Algorithm, Chirp-Z Algorithm, Split Radix FFT*	
02.	**Digital filters**	**06-08**
	Learning Objective: ***1.*** *To design and analyze the digital filter for given specifications using modern tools*	
	Experiment: a. Utilize the windowing method to design the FIR filter and use them to filter the input b. Design IIR low-pass digital filter and plot its magnitude response. ***Learning Outcomes:*** *A learner will be able to* *LO 2.1: Design an appropriate digital filter (FIR/ IIR) for the given specification. (PI 2.1.2), (PI 5.2.2)* *LO 2.2: Systematically analyze the response with change in parameters. (PI 4.1.4), PI(4.3.1)* c. To study the effect of coefficient quantization on the frequency response of an IIR filter. *LO 2.3: Analyse the effect of hardware limitations on the performance of the system. (PI 2.4.2) (PI 5.1.2)*	
	Self-Learning Topics: --	
03.	**Audio and Biomedical signal processing**	**04-06**
	Learning Objectives: ***1.*** *To apply the signal processing techniques for audio and biomedical signal processing.*	
	Experiment : **Audio Signal processing:** a. To generate Echo and reverberation effects on audio signal b. Demonstration of Multirate Signal Processing for audio mixing c. Removal of high frequency noise from Speech signals using Haar filter bank	

	d. Audio Equalizers **Biomedical Signal Processing:** a. QRS separation using FIR filters and Moving Average filters b. Computation of Heart rate and Classification of ECG signals c. Envelop detection using Hilbert transform d. QRS separation using template matching e. Denoising of ECG/EMG/EEG signals	
	Self-Learning Topics: *--*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: To demonstrate advanced signal processing concepts for Music and Speech signal processing (PI 4.1.3), (PI 5.2.2), (PI 2.4.4)* *LO 3.2: To design appropriate filters for the denoising the given audio or biomedical signal (PI 2.2.3), PI(5.1.2)*	
04.	**Signal Processing applications in communication**	**02**
	Learning Objectives: ***1.*** *To guide students in implementing signal processing applications in Communication domain..*	
	Experiment : a. Split Radix FFT in OFDM b. Designing a digital SSB modulator.	
	Self-Learning Topics: Split Radix FFT	
	Learning Outcomes:	
	A learner will be able to *LO 4.1: To implement advanced signal processing concepts for communication related applications (PI 4.1.3), (PI 5.2.2), (PI 2.4.4)* *LO 4.2: To design appropriate systems for the applying the signal processing concepts to signal (PI 2.2.3), PI(5.1.2)*	
05.	**Software Assignment** **Learning Objective/s***:* *To give the students an exposure to implementing signal processing techniques for real world application.* *The software assignment can be done in a group of 3-4 students.* *Learning Outcomes:* *A learner will be able to* *1. LO 5.1: Analyze the sourced technical literature to formulate an appropriate problem statement pertaining to societal relevance (PI 11.1.3)(PI 6.1.1)* *2. LO 5.2:Develop optimal engineering design solutions for the formulated problem, applying troubleshooting and critical thinking skills and present the results as a team. (PI 3.2.1) (PI 3.3.3)PI(8.3.1)PI(9.1.2) (PI 2.4.3),PI(2.1.1)*	**04-06**
	Total	**30**
Module 1 : Any 3 ; Module 2 : all 3 **Module 3 : Any 2** **Module 4 Any one Module 5 : One course project**		

Performance Indicators:

P.I. No.	**P.I. Statement**
1.1.2	Apply mathematical transforms to solve problems.
1.4.1	Apply concepts of electronics and communication engineering and allied disciplines to solve engineering problems.
2.1.1	Articulate problem statements and identify primary objectives and key constraints.

2.1.2 Identify engineering systems, variables, and parameters to solve the problems
2.3.2 Identify assumptions (mathematical and physical) necessary to allow modeling of a system at the level of accuracy required.
2.4.1 Apply engineering mathematics and computations to solve mathematical models
2.4.2 Produce and validate results through skilful use of contemporary engineering techniques.
2.4.3 Identify sources of error in the solution process, and limitations of the solution.
2.4.4 Extract desired understanding and conclusions consistent with objectives and limitations of the analysis
3.1.6 Determine design objectives, functional requirements and arrive at specifications
3.2.1 Apply formal idea generation tools to build models/prototypes in order to develop multiple engineering design solutions.
3.3.3 Identify relevant data from the given resources and arrive at an optimal design solution for particular specifications.
4.1.3 Apply appropriate instrumentation and/or software tools to make measurements of physical quantities.
5.2.2 Demonstrate proficiency in using discipline-specific tools.
6.1.1 Identify environmental and health issues related to engineering profession with the help of relevant viewpoints from stakeholders and propose solutions.
8.3.1 Present results as a team, with smooth integration of contributions from all individual efforts
9.1.2 Create clear, well-constructed, and well-supported written engineering documents and/or presentation.
11.1.3 Develop ability to learn independently through methods distinct from instructor provided materials.

Course Outcomes: A learner will be able to -

1. Demonstrate the use of Discrete Fourier Transform (DFT) concepts and properties to analyze real-time signals using modern tools, efficiently represent them in the frequency domain, and perform linear filtering of long data sequences. *(LO 1.1, LO 1.2, LO 1.3)*
2. Design digital filters for given specifications, analyze them w.r.t. response variations, hardware limitations on system performance. *(LO 2.1, LO 2.2, LO 2.3)*
3. Implement digital filters for real world signal processing applications using appropriate software tools. *(LO 3.1, LO 3., LO 4.1, LO 4.2)*
4. Develop software prototypes for engineering solutions to real world problems, collaborate in teams, and apply critical thinking to troubleshoot challenges. (*LO 5.1, LO 5.2)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ECLBC609.1	3	2			2	2					
ECLBC609.2		3		3	3						
ECLBC609.3		3		2	3						
ECLBC609.4		3	3					2	2		2
Average	3	3	3	3	3	2		2	2		2

Text Books :

1. Emmanuel C. Ifeachor, Barrie W. Jervis," Digital Signal Processing", A Practical Approach", Pearson Education
2. Dr. K.N. Hari Bhat, Digital Communication , 2nd ED. Pearson Education .
3. Mitra SK. Digital signal processing: a computer-based approach. McGraw-Hill Higher Education; 2001 Jul 1.

4. Rangayyan RM, Krishnan S. Biomedical signal analysis. John Wiley & Sons; 2024 Feb 19.

Reference Books :

1. Sanjit K. Mitra, "Digital Signal Processing – A Computer Based Approach", 4th Edition McGraw Hill Education (India) Private Limited.
2. Dart-Enander E, Part-Enander E, Sjoberg A. The MATLAB 5 handbook. Addison-Wesley Longman Publishing Co., Inc.; 1999 Sep 1.
3. Chapman SJ. MATLAB programming for engineers. Brooks/Cole Publishing Co.; 2001 Nov 1.

A. IN-SEMESTER ASSESSMENT (25 MARKS)

Suggested breakup of distribution

Practical Exercises- 10 Marks

Internal Assessment-
Practical Test1 (Based on first 50 % of the Practical list) – 5 Marks
Software Assignment on real time signals: 5 Marks
Regularity and active participation - 5 Marks

B. END SEMESTER ASSESSMENT (Pract./Oral Exam) (25 Marks)

Students will be assessed based on three parameters:

- Conceptual knowledge
- Practical knowledge
- Oral

- Students will be randomly allocated a problem statement from the list of laboratory exercises and will be asked to draw the circuit diagram / block diagram along with the expected results and observations. The written content is checked by the examiners (Internal and External) and evaluated out of 05 Marks.

  Then the student will be allowed to start with the implementation of the experiment.

- Students will be allocated 1 hour to complete the execution. The output is then checked by both the examiners for its correctness. The weightage of the implementation is 10 Marks.

- Students will then be appearing for Oral in front of both Internal and External examiners. The weightage of Oral will be of 10 Marks.

Two examiners, one Internal and one External will do the evaluation.

Course Type	Course Code	Course Name	Credits
SBL	ECSBL603	IMAGE PROCESSING & MACHINE VISION LABORATORY	02

Examination Scheme			
Distribution of Marks		Exam Duration (Hrs.)	Total Marks
In-semester Assessment	End Semester Examination (ESE)	ESE	
50	50	2	100

Pre-requisite:

1. ECSBL301: Python Laboratory
2. ECPCC509: Signals & Systems

Program Outcomes addressed:

1. PO 1: Engineering knowledge
2. PO 2: Problem analysis
3. PO 3: Design/Development of Solutions
4. PO 4: Conduct investigations of complex problems
5. PO 5: Modern tool usage
6. PO 6: Ethics
7. PO 8: Individual and teamwork
8. PO 9: Communication
9. PO 11: Life-long learning

Course Objectives:

1. Develop a foundational understanding of image processing and machine vision techniques, including image acquisition, pre-processing, enhancement, and feature extraction.
2. Gain practical experience in implementing image processing algorithms using tools and programming environments like Python, or OpenCV to solve real-world problems.
3. Apply machine vision concepts to automate tasks such as object detection, pattern recognition, and quality control in various industrial and research settings.
4. Review relevant research papers, datasets, and industry case studies to gain insights into the latest advancements in 3D vision.

Module	Details	Hrs.
	Course Introduction Engineering roles that require knowledge of image processing and machine vision are in demand across various industries, including autonomous vehicles, robotics, healthcare, manufacturing, AI/ML, AR/VR, and surveillance. These engineers develop systems and algorithms to interpret, analyse, and act upon visual data in real-time,	**01**

	often integrating cutting-edge technologies like deep learning and 3D vision. Familiarity with tools such as OpenCV, MATLAB, Python is crucial for success in these roles. This course is a beginner's course which takes the learner through basics of images, their space-and frequency-domain processing, segmentation techniques, feature extraction and finally 3-D vision/depth estimation. The content is oriented in such a way that learner will develop self-learning ability through spoken tutorials, programming skills by implementing various techniques and creative skills through a case study presentation**.**	
01.	**Handling Images in Software** ***Learning Objective:*** ***To teach the basics of image formats, reading, manipulation, and performance metrics in image processing using open source software.***	**11-13**
	Demonstrations on 1. Types of images, reading-writing images, elementary manipulation of image pixels, importance of image datasets 2. Performance metrics and their significance **Suggested Tasks** 1. Use Python libraries to perform elementary pre-processing operations—such as resizing to 256×256, converting to grayscale, and normalizing pixel intensities to the 0–255 range—on a set of medical images, and save the results as a new pre-processed dataset .(LO1.1) 2. Students will be able to prepare a binary watermark logo, embed it into a dataset of images, compute performance metrics such as Mean Squared Error (MSE) between original and watermarked images, interpret the results, and document their findings. (LO 1.2)	
	Self-Learning Topics: Image resolution and Geometric transformations of images	
	Learning Outcomes: *A learner will be able to* *LO 1.1: use Python libraries to perform elementary pre-processing operations on a bunch of images sequentially, and prepare a pre-processed dataset of manipulated images. (PI 1.4.1, 5.1.1)* *LO 1.2: evaluate performance metrics, interpret their results and report in a technical document following technical writing ethics. (PI 2.4.4, 7.1.1, 9.1.2)* *Report rubric: Python programming, Accuracy of resultant datasets, Accuracy of performance metric interpretation, Quality of report, Ethics in writing.*	
02.	**Image Enhancement in Spatial and Frequency Domain** ***Learning Objective:*** 1. ***To apply spatial and frequency domain image processing techniques for enhancement, filtering, and restoration.*** 2. ***Develop hands-on skills in image segmentation, feature extraction, and transformation techniques for practical applications in image analysis.***	**15-17**

Demonstrations on:

1. Transformations operating on image and their significance.

2. Spatial domain enhancement techniques: point processing, histogram equalization, spatial domain filters: smoothening and sharpening filters, mean, weighted averaging, median, min, max, Laplacian.

3. Images in frequency domain, Image transforms and filter design in frequency domain

Suggested Tasks

1: Degradation and Restoration of (Medical) Images Using Spatial Domain Techniques

You are provided with a pre-processed, watermarked medical image dataset. Your task is to simulate real-world degradation scenarios and implement restoration techniques using spatial domain methods. Design and implement custom Python functions to build spatial filters with specified kernels. Apply various spatial filters such as mean, max, min, and median to restore the noisy images. Analyze the filtering results using both qualitative visualization and simple quantitative measures .(**LO 2.1)**

2: Image Enhancement in Frequency Domain and Interpretation of Results

Working with degraded images generated previously, implement image enhancement techniques using frequency domain filtering. Apply histogram equalization to enhance dull images and use advanced filtering methods like Laplacian of Gaussian (LoG) on external sample images (e.g., "rice.png") to highlight edge and detail information. Additionally, implement and analyze the effects of ideal, Butterworth, and Gaussian filters in both low-pass and high-pass configurations using OpenCV and related Python libraries. Evaluate how each filtering method affects image clarity and structure. Interpret the results by comparing visual features and quantifiable metrics .(LO 2.2)

Self-Learning Topics: Image Restoration

Learning Outcomes:
A learner will be able to

LO 2.1: use appropriate Python libraries to perform given tasks, write the required functions with proficiency and call them using driver function. (PI 5.2.2)

LO 2.2: Implement spatial and frequency domain enhancement methods using contemporary Python packages like OpenCV, matplotlib; interpret the obtained results and report in a technical document following technical writing ethics. (PI 2.4.2, 5.1.1, 7.1.1, 9.1.1)

Report rubric: Python programming proficiency, Accuracy of resultant operations, Accuracy of interpretation of results obtained, Quality of report, Ethics in writing.

03.	**Image Segmentation and Morphology**	**13-15**

Learning Objective:

1. ***Understand and apply segmentation techniques such as thresholding, clustering, and deep learning to extract meaningful regions from images.***

2. ***Develop practical skills in feature extraction and object detection for real-world applications like medical imaging, satellite analysis, traffic monitoring, and quality inspection***.

Demonstrations on:

1. Edge detection operations: Prewitt, Sobel, Laplacian, Canny. and segmentation methods: Threshold based segmentation, k-means clustering

2. Morphological operations: erosion, dilation, opening, closing, skeletonization, boundary detection, morphological gradient, hit-and-miss transform

Suggested Tasks:

1. Detection of White Blood Cell and Red Blood Cell is very useful for various medical applications, like counting of WBC, disease diagnosis, etc. Circle detection is the most suitable approach. Implement Canny edge detection and feature extraction techniques for blood cell identification, on the enhanced image using techniques learnt in module II.
2. In Medical Imagery, medical professionals view inside the human body in order to diagnose, monitor, and treat. There are various techniques available in the modern scientific age. A popular technique is MRI: Magnetic resonance imaging. Given an MRI image, perform **morphological segmentation** for separating the brain part, using open-source tool Octave.
3. Implement segmentation on an image from the Google Earth dataset for indicating regions of water bodies, forests, urban areas, and farmlands using **K-means clustering**.

For the above mentioned tasks:

1.Identify relevant sub-process (noise reduction, image smoothening, edge linking etc) (LO 3.1)

2. implement appropriate image enhancement and segmentation techniques (LO 3.2)

3. Prepare well documented report with the interpretation of finding for the above two tasks. (LO 3.3)

Self-Learning Topics: Watershed algorithm, Otsu's algorithm

Learning Outcomes:
A learner will be able to

LO 3.1: identify relevance of techniques learnt in practical applications and formulate sub-processes to achieve the goal specified in the tasks. (PI 6.1.1, 4.1.1)

LO 3.2: apply the image enhancement techniques learnt in previous module without any assistance to the tasks in this module and implement appropriate segmentation algorithms to achieve goal of the task. (PI 1.4.1, 5.2.2)

LO 3.3: Prepare a meaningful interpretation of the results obtained and provide in the form of a well-documented report following technical writing ethics. (PI 7.1.1, 9.1.1)

	Report rubric: Application of image enhancement techniques, Python proficiency in performing segmentation, Accuracy and interpretation of results, Quality of report, Ethics in writing.	
04.	**Object Detection, 3D Vision and Depth Estimation** ***Learning Objectives:*** ***To provide knowledge about state-of-the-art methods for depth estimation.***	**15-17**
	Demonstrations on: 1. YOLO for Object Detection 2. Depth estimation between object and camera 3. Introduction to depth estimation: Hardware based techniques like LiDAR and software-based techniques like Multi-view geometry **Suggested Tasks:** • **Case-studies (Any one)** **1.** Corner detection methods: Harris corner detection, Shi-Tomasi corner detection **2.** Texture analysis of images for feature extraction **3.** Transform features (Fourier, Wavelet, DCT) **4.** Local feature descriptors (SURF, SIFT) **5.** The original paper on YOLO (1506.02640) 6. Autonomous Vehicles: 3D Depth Perception for Object Detection (Resources: KITTI Dataset, https://ieeexplore.ieee.org/document/6957799) 7. Robotics: 3D Vision for Object Manipulation (Resources: "3D Vision-Based Object Grasping for Robotic Manipulation" – Robotics Journal, Open3D Library for 3D Vision (https://www.open3d.org/) • **Course Project**	
	Self-Learning Topics: Society/healthcare/law enforcement/governance related applications of image processing and machine vision for course project.	
	Learning Outcomes: *A learner will be able to* *LO 4.1: read, interpret and report the given case-study based on the provided resources in the broader context of applications of the case-studies in real-life. (Individual activity) (PI 6.1.1, 9.1.2, 11.1.3)* *LO 4.2: Collaboratively apply image processing techniques learned in the course to design and implement solutions for real-life tasks, demonstrating teamwork, problem-solving skills and report writing skills. (PI 3.1.6, , 8.1.2, 9.3.3).*	
	Course Conclusion	**01**
	Total	**60**

Performance Indicators:

P.I. No.	P.I. Statement
1.4.1	Apply concepts of electronics and communication engineering and accepted practice areas to solve engineering problems.
2.1.1	Articulate problem statements and identify primary objectives and key constraints.
2.4.2	Produce and validate results through skilful use of contemporary engineering techniques.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis.
3.1.6	Determine design objectives, functional requirements and arrive at specifications.
3.2.2	Identify suitable criteria for evaluation of alternate design solutions.
4.1.1	Define a problem, its scope, and importance for purposes of investigation.
4.1.2	Examine the relevant methods, tools, and techniques of experiment, design, system calibration, data acquisition, analysis and presentation
5.1.1	Identify modern hardware and software engineering tools, techniques and resources for engineering activities.
5.2.2	Demonstrate proficiency in using discipline-specific tools.
6.1.1	Identify social, environmental and health related issues with the help of relevant viewpoints from stakeholders and propose engineering solutions.
7.1.1	Follow ethical practices to create a document.
8.1.2	Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective teamwork, to accomplish a goal.
9.1.1	Read, understand and interpret technical and/or non-technical information.
9.1.2	Create clear, well-constructed, and well-supported written engineering documents and/or presentation.
9.3.3	Comprehend literature, carry out background search and prepare a paper/patent draft.
11.1.3	Develop ability to learn independently through methods distinct from instructor provided materials.

Course Outcomes: A learner will be able to -

1. Apply techniques in image processing and machine vision to analyse given task, identify requirements and perform them. (LOs: 1.1, 1.2, 2.2, 3.2, 4.2)
2. Use open-source software Octave and contemporary Libraries in Python to implement the tasks proficiently with meaningful interpretation of results obtained. (LOS: 1.1, 2.1, 3.2, 4.2)
3. Prepare good quality technical report based upon each task, case study and course project following ethical principles in technical writing. (LOs: 1.2, 2.2, 3.2, 3.3, 4.2)
4. Identify resources, choose appropriate real-life problem related to image processing & machine vision, and use software tools efficiently to develop solution for the problem. (LOs 4.1, 4.2)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ECSBL601.1	2	3	---	2	2	---	---	---		---	---
ECSBL601.2	---	---	---	---	2	---	---	---	3	---	---
ECSBL601.3	---	---	---	---	---	---	2	---	3	---	2
ECSBL601.4	---	---	2	---	2	2	---	---		---	2
Average	2	3	2	2	2	2	2	---	3	---	2

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books:

1. **Digital Image Processing** by Rafael C. Gonzalez and Richard E. Woods.
2. **Learning OpenCV 4: Computer Vision with Python** by Gary Bradski and Adrian Kaehler.

Reference Books:

1. **Computer Vision: Algorithms and Applications** by Richard Szeliski.
2. **Programming Computer Vision with Python** by Jan Erik Solem.

Other Resources:

1. OpenCV documentation: OpenCV: OpenCV modules
2. Kaggle Datasets: Find Open Datasets and Machine Learning Projects | Kaggle

A. IN-SEMESTER ASSESSMENT (50 MARKS)

Suggested breakup of distribution

a. Practical Exercises and case study report - 10 Marks

Students will be given number of experiments as mentioned in the syllabus. Each experiment carries 10 Marks. Average will be taken of all experiments. Students are expected to listen to the spoken tutorials and perform the assigned tasks in the experiments as per requirement. They are expected to prepare a brief report of each experiment, which includes the task description, program, results obtained, discussion on results and conclusion.

b. Mid-term Test: 15 Marks

Students will be allotted a Test-paper based upon first two modules individually. Tasks will be evaluated for proficiency in coding, accuracy of results and concluding answers provided for the questions asked in the task-sheet.

c. Course project presentation– 20 Marks

Students will be allotted Course project in a group of two-to-three students from a batch. The case study will be based on module 6 whereas course project will be based on techniques learnt in the entire course. The presentation will be carried out for 35 marks. The guideline for assessment is as follows.

i. Clarity in presenting the objectives: 10 marks (Group assessment)

ii. Lucidity in explanation of methodology and results: 20 marks (Individual assessment)

iii. Q/A: 5 marks (Individual assessment)

d. **Regularity and active participation - 5 Marks**

B. END SEMESTER EXAMINATION (50 Marks)

Unified task execution: 30 marks

Learner will be given problem statements which interlink learning outcomes of multiple modules from module 1 to 5. Learner will be expected to perform the tasks given in the problem statement individually and demonstrate results. The assessment will be on following parameters;

i. breaking down the complex problem in smaller parts: 6 marks

ii. executing the small tasks correctly: 10 marks

iii interlinking the results of smaller tasks to perform the unified task correctly: 10 marks

iv presenting the results in a clearly written report: 4 marks

Example: A dataset containing 10 images is provided to you. Resize all the images to 64x64, perform smoothening on all the images and generate feature vector of SIFT features from the smoothened images. Display all the three stages as images.

Viva-voce on the course-modules: 20 marks

Two examiners, one Internal and one External will do the ESE evaluation.

Course Type	Course Code	Course Name	Credits
MNP	ECMNP604	MINI PROJECT- 2B	01

Program Outcomes addressed:

1. PO1 : Engineering knowledge
2. PO2 : Problem Analysis
3. PO3 : Design/Development of Solutions
4. PO4 : Conduct investigations of complex problems
5. PO5 : Engineering Tool Usage
6. PO6 : The Engineer & World
7. PO7 : Ethics
8. PO8 : Individual & Collaborative team work
9. PO9: Communication
10. PO10: Project Management & Finance
11. PO11: Life-long learning

Course Objectives:

1. To guide students in identifying societal or research needs and formulating them into problem statements.
2. To facilitate problem-solving in group settings.
3. To apply basic engineering principles to address identified problems.
4. To foster self-learning and research skills.

Course Outcomes:

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

1. Identify problems based on societal or research needs and methodology for solving them.
2. Apply knowledge and skills to solve societal problems collaboratively.
3. Develop interpersonal skills necessary for teamwork.
4. Analyze, verify, and validate results effectively through various methodologies, including, test cases/benchmark data/theoretical/inferences/experiments/simulations, etc.
5. Evaluate the societal and environmental impacts of proposed solutions.
6. Adhere to standard engineering practices.
7. Excel in written and oral communication by technical report writing, oral presentation, and publishing results in
   - Research/white paper/article/blog writing/publication, etc.
   - Business plan for entrepreneurship product creation
   - Patent filing/copyright.
8. Gain technical competencies by participating in competitions, hackathons, etc.
9. Demonstrate lifelong learning capabilities through self-directed group projects.
10. Apply project management principles effectively.

Guidelines for the Mini Project

• Mini project may be carried out in one or more form of following:
Product preparations, prototype development model, fabrication of set-ups, laboratory experiment development, process modification/development, simulation, software development, integration of software (frontend-backend) and hardware, statistical data analysis, creating awareness in society/environment etc.
• Students must form groups of 3 to 4 members either from the same or from different departments.
• Groups should conduct surveys to identify needs and develop problem statements in consultation with faculty.
• An implementation plan in Gantt/PERT/CPM chart format covering weekly activities must be submitted.
• Each group must maintain a logbook to record weekly progress, to be verified by the faculty supervisor.
• Faculty input should emphasize guiding by faculty and self-learning by group members.
• Groups should propose multiple solutions, select the best one in consultation with the supervisor, and develop a working model.
• The solution to be validated with proper justification and report to be compiled in standard format of the Institute. Software requirement specification (SRS) documents, research papers, competition certificates may be submitted as part of annexure to the report.
• With the focus on self-learning, innovation, addressing societal/research/innovation problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality be carried out in two semesters by all the groups of the students.
• However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above, gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on a case by case basis.

In-Semester Continuous Assessment and End-Semester Examination Guidelines

- The Head of the Departments will assign a guide to each of the mini-projects and shall form a progress monitoring committee. The guide will carry out weekly monitoring of the project's progress. The committee shall carry out in-semester project evaluation based on presentations with a minimum of two evaluations per semester.
- Assessment will be based on individual contributions, understanding, and responses to questions asked.
- Continuous Assessment marks distribution in semester VI (50 marks):
    - 20 marks for the In-Semester Two Presentations
    - 05 marks for Participation in Project Competitions, TPP, etc.
    - 20 marks for the Final Report & Presentation
    - 05 marks for Regularity and active participation

The review/progress monitoring committee will assess projects based on the following criteria.

Semester VI:

- Expected tasks include procuring components/systems, constructing a working prototype, and validating results based on prior semester work.

- Reviews will be conducted as follows:
  - The first review will assess the readiness to build a working prototype.
  - The second review will involve a poster presentation and demonstration of the working model in the last month of the semester.

In addition to above mentioned points, the following performance criteria shall be included during in-semester continuous assessment:

1. Quality of survey and need identification.
2. Clarity and innovativeness in problem definition and solutions.
3. Requirement gathering via SRS/feasibility study, cost-effectiveness, and societal impact of proposed solutions.
4. Completeness and full functioning of the working model.
5. Effective use of skill sets and engineering norms.
6. Verification & validation of the solutions/test cases.
7. Individual contributions to the group.
8. Clarity in written and oral communication.
9. Participation in technical paper presentation/project competitions/hackathon competitions, etc.

End-Semester Examination in Semester VI (50 marks):

1. Presentation and demonstration to internal and external examiners: 20 marks.
2. Emphasis on problem clarity, innovativeness, societal impact, functioning of the model, skill utilization, and communication clarity: 30 marks.

Course Type	Course Code	Course Name	Credits
ELC	ELC601	Research Methodology	02

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
50	--	--	--	--	50

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO6: The Engineer & The World.
4. PO7: Ethics
5. PO8: Individual & Collaborative team work
6. PO9: Communication
7. PO11: Life-long learning

Course Objectives:

1. To gain the knowledge of use research tools and techniques to design research projects and form the hypothesis.
2. To familiarize students about the literature review practice for identifying the research gap.
3. To gain the knowledge about collection of data and qualitative/ quantitative analysis of data and results
4. To understand the key practices in preparation of a research report / paper.
5. To foster ethical practices in research and publications

Module	Details	Hrs
00	**Course Introduction:** This course aims to introduce students to the important aspects of research. The course is intended to make students aware of formal research and to overcome common misconceptions in research that may be present in their minds. At the end of this course, students shall be able to take up research activities in a more systematic and formal manner right from the beginning. This course on Research Methodology learned through experiential learning mechanism can play a significant and holistic role in contributing to the personal and professional development of students.	1
1	**Fundamentals of Research Methodology**	4-5
	Content: Types of Research, Research approaches, Empirical research methods, Significance of research, Research design, Case study method, Sampling technique, Sources of data, Selection of research problem, Research Ethics and Empiricism *Exercise: A group discussion on what is research and ethics in research with related case studies shall be conducted.*	
2	**Formulation of a Research Problem & Hypothesis formulation**	4-5

	Content: Selection and formulation of a research problem, Objectives of formulation, Criteria of a good research problem, Literature Review Process and Formulation of Research Questions Hypothesis-Characteristics and Hypothesis Testing –Logic and Importance *Exercise: Groups of students shall make Technical Presentations on Selection of a research problem and Hypothesis formulations based on topics given.*	
3	**Research Design**	**4-5**
	Content: The Research framework, Research design: Need, Characteristics & Components; Experimental and non-experimental designs, Experimental and non-experimental hypothesis testing. Classification schemes for research design, Principles of experimental designs, Writing rationale for a research *Exercise: Students shall prepare the framework of research methods and techniques to conduct a study on a given real life case study covering key elements of the module.*	
4	**Sampling Method**	**3-4**
	Content: Probability or random sampling, Cluster sampling, Area sampling, Multi-stage sub-sampling, Random sampling with probability proportional to size, Non-probability sampling. *Exercise: A real life case study shall be demonstrated to students covering key elements of the module shall be covered.*	
5	**Data Collection & Data Analysis**	**4-5**
	Content: Sources of data, Collection of data, Measurement and scaling technique, Collection of data from appropriate sources (primary and secondary), Correlation and causation, Classification of quantitative analysis. Selection and analysis of multi-variate methods, Performing data analysis and presentation of results, Case study method. *Exercise: Group of students shall carry out exercise of real life data collection on a given research problem and data analysis and submit the report*	
6	**Report Writing and Journal Publication**	**3-4**
	Content: Preparation of a research report, Formats and Contents of report: Literature review, Presentation of research work, Research Design & Analysis, Results, Findings, and Contribution, Significance of research, and Conclusion. Mechanics of writing papers in Peer-reviewed Journals / Reputed Conferences. Ethics in Publication. *Exercise: Students shall prepare & submit a paper (4-5 pages) in a standard format (suitable universally accepted journal publication format) based on the exercises / research case study carried out in this course.*	
7	***Course Conclusion***	**1**
	Total	**30**

Course Outcome: Learner will be able to

CO1: Identify and demonstrate the importance of research process in science and technology domains
CO2: Perform literature reviews using print and online databases.
CO3: Analyse the data using qualitative and quantitative methods
CO4: Identify and prepare the key elements of a research report/ paper
CO5: Illustrate the rationale for research and publication ethics

Text Books:

1. C. R. Kothari and Gaurav Garg, Research Methodology: Methods and Techniques, New Age International Publisher, 2014.
2. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, Sage Publication, 2018
3. R. Pannershelvam, Research Methodology, Prentice Hall, India, 2014

Reference Books:

1. John W. Creswel, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 4th Ed., SAGE, 2018.Geoffrey R. Marczyk, David DeMatteo & David Festinger, Essentials of Research Design and Methodology, John Wiley & Sons, 2005.
2. Suresh C. Sinha and Anil K. Dhiman, Research Methodology (2 Vols-Set), Vedam Books, 2006.
3. Manfred Max Bergman, Mixed Methods Research, SAGE Books, 2006.
4. Paul S. Gray, John B. Williamson, David A. Karp, John R. Dalphin, The Research Imagination, Cambridge University press, 2007.
5. Cochrain & Cox, Experimental Designs, II Edn. Wiley Publishers, 2006

Other Resources:

NPTEL Course: Research Methodology By Prof. Edamana Prasad, Prof. Prathap Haridoss (IIT Madras)
Weblink https://onlinecourses.nptel.ac.in/noc25_ge28/preview

Course Type	Course Code	Course Name	Credits
LLC	LLC6011	ART OF LIVING	02

Program Outcomes addressed:

1. PO6 : The Engineer & The World
2. PO7 : Ethics
3. PO8 : Individual and Collaborative Team Work
4. PO9: Communication
5. PO11: Life-long learning

Course Objectives :

1. To provide a comprehensive understanding of the principles of the Art of Living and their relevance to holistic well-being.
2. To equip participants with practical techniques like Sudarshan Kriya, yoga, and mindfulness for stress management and emotional balance
3. To enable participants to apply the Art of Living principles to enhance relationships, productivity, and life purpose.

Module	Details
01.	**Introduction to the Art of Living** Understanding the Mind and Stress, Breath and Life Energy, Basics of Yoga and Guided Meditation
02.	**Sudarshan Kriya and Breathing Techniques** Introduction to Sudarshan Kriya, Practicing Rhythmic Breathing Techniques
03.	**Emotional Well-being** Understanding and Balancing Emotions, Forgiveness and Gratitude Practices, Guided Meditation for Emotional Healing
04.	**Relationships and Social Connections** Compassion and Effective Communication, Stress-free Relationships, Group Activities for Trust and Collaboration
05.	**Living with Purpose and Awareness** Discovering Life Purpose, Mindfulness Practices, Time Management and Productivity
06.	**Sustaining the Practices** Developing a Daily Routine, Advanced Breathing Techniques, Reflections, and Closing Meditation
Total no. of hours: **30**	

Course Outcomes :

1. Gain insights into managing stress and emotions through breathwork and meditation
2. Develop skills for building harmonious relationships and enhancing emotional intelligence.
3. Cultivate mindfulness, compassion, and clarity in daily life.
4. Sustain the Art of Living practices for long-term well-being and self-discovery.

Text Books :

1. "Celebrating Silence" by Sri Sri Ravi Shankar (1999, Sri Sri Publications Trust)
2. "The Heart of Yoga: Developing a Personal Practice" by T.K.V. Desikachar (1995, Inner Traditions International)
3. "The Miracle of Mindfulness" by Thich Nhat Hanh (1975, Beacon Press)

Reference Books :

1. "Wisdom for the New Millennium" by Sri Sri Ravi Shankar (2000, Sri Sri Publications Trust)
2. "The Healing Power of the Breath" by Richard P. Brown and Patricia L. Gerbarg (2012, Shambhala Publications)

Course Type	Course Code	Course Name	Credits
LLC	LLC6012	Yoga and Meditation	02

Program Outcomes addressed:

1. PO6: The Engineer and The World
2. PO7: Ethics
3. PO11: Life-Long Learning

Course Objectives:

1. To raise awareness of the therapeutic and preventive benefits of Yoga and Meditation
2. To nurture Holistic wellness through the harmony of body, mind and self
3. To advocate for the application of Yogic science in the treatment and prevention of psychosomatic and Lifestyle disorders.
4. To inspire the practice of Yogic Science tools for fostering health and well-being in daily life.
5. To promote the art of purposeful and mindful living by cultivating a deep sense of oneness with the self, nature and the world.

MODULE	DETAILS
1.	**Introduction to Yoga and Meditation** Definition of Yoga, Importance of Yoga for Human life, Literature of Yoga: Yoga Sutra, Bhagavat Gita – Synthesis of Yoga, Hathapradipika etc. Challenges of health in students & youth - Studies, Yogic concept of Health and Meditation, Concept of Body and Disease in Yoga, Dimensions of Health- Physical, Mental, Social and Spiritual, Different types of yoga (Karma, Gyaan, Ashtanga, Bhakti), Eight limbs of ashtanga yoga.
2.	**Yoga and Wellness** Yoga and Medical perspectives – Health related fitness, Yoga for common ailments, Scientific Researches in Yoga, Yogic anatomy of Human body, Asanas – Definitions and classifications, Scientific reasoning behind the asanas, Yoga for Stress, Technostress and Lifestyle management. Mental Disturbances and Preventive, Curative Aspect of Yoga for Mental wellness.

3.	**Essentials of Yoga Practices** Difference between Yoga and Exercise, Obstacles in the path of Yogic Practices, Disciplines in Yogic practices – Prayers, Yama, Niyama, Place, Time, Diet, Schedule, Sequence for Yogic Practices. Yogasanas: Surya Namaskara, Standing asanas and Sitting asanas, Different groups of Yogasanas – Relaxation, Meditative, Digestive etc. Psycho-physiological effects and health benefits of Yogasana, Function and effect of Asanas - Digestive system, Respiratory system, Excretory system, Circulatory system, Nervous system etc.
4.	**Meditation – Role of Breath and Pranayama** Yogic anatomy, Wellness and Triguna system, Science of Pranayama – 'Prana', the vital principle, Prana and air element, Awareness - Breath Awareness, Different types of Breathing, Breath Control, Breath and Postures, Rhythmic Breathing, Pranic body in the five-fold body (Panchakosha), Power of breath, Difference between Pranayama and breathing, Prana and nervous system, Fivefold function of prana, Benefits of pranayama
5.	**Fundamental aspects of Meditation** Pranayama and deep breathing - Concept of Inhalation (Puraka), Retention (Kumbhaka), & Exhalation (Rechaka); Important Pranayamas; Pranayama and Meditation; Mind and Meditation; Inner Instrument – Mind, Constituents of Mind - Mana, Buddhi, Ahankar and Chitta(Consciousness), Magnitude of Mind, Buddhi – the determinative faculty; Body-Mind complex; Mind Cleansing; Yogic Meditation and Mindfulness meditations; Yogic Process and Outcome of Meditation – Pratyahara, Dharana and Dhyana; Scientific studies on Meditation and Healing.
6.	**Meditation Tools and Techniques** Why Meditate - States of Mind, Mind over Body – Processing Thoughts, Preparing for Meditation – Posture, Shanti prayers, Pranayama, Training the Mind: Practicing tools- Bhramari Pranayama, Sacred Pranav (Om) mantra, Mantra Japa/ajapa, Types of Mindfulness Meditations, Yoga Nidra, Body scan meditation, etc. Benefits of Meditation

Course Outcomes:

1. Gain comprehensive insights about the necessity of yoga for daily life.
2. Obtain a simplified understanding of the impact of mindful breathing on health wellbeing.
3. Acquire knowledge of 'practice and principles' of simple awareness meditation for Mental wellness
4. Gain required knowledge to improve overall health and immune system
5. Practice simple asanas and meditation techniques to improve concentration, self- confidence and inner peace

Text Books:

1. Light on the Yoga Sutras of Patanjali by B.K. Iyengar (Publisher: Orient Longman Pvt. Ltd. Mumbai)
2. Pranayama - The Art & Science by Dr. Nagendra H R (Publisher: Swami Vivekananda Yoga Prakashan, Bangalore)
3. Yog – Its Philosophy and Practice by Swami Ramdev (Publisher: Divya Prakashan, Haridwar)

Recommended Books

1. Pranayama-Science of Breath by Gharote, M. (Publisher: The Lonavla Yoga Institute, India)
2. Svatmarama's HathaYogaPradeepika by Gyan Shankar Sahay (Publisher: Yogic Heritage, India)
3. Yoga for Health and Peace by Padamshree Sadashiv Nimbalkar (Publisher: Yoga Vidya Niketan, Mumbai)

Other Resources:

1. NPTEL Course: Yoga and Positive Psychology for Managing career and life by Prof. Ashish Pandey, IIT Bombay.
Weblink https://archive.nptel.ac.in/courses/110/101/110101165/

2. SWAYAM Course: Yoga for Concentration by By Dr H R Nagendra, Dr Manjunath N K and Dr Apar Avinash Saoji from Swami Vivekananda Yoga Anusandhana Samsthana, Bangalore.
Weblink: https://onlinecourses.swayam2.ac.in/aic23_ge05/preview

Course Type	Course Code	Course Name	Credits
LLC	LLC6013	Health and Wellness	02

Program Outcomes addressed:

1. PO6: The Engineer and The World
2. PO7: Ethics
3. PO11: Life-Long Learning

Course Objectives:

1. To advocate for the significance of Holistic wellness
2. To enhance all dimensions of wellness through the lens of scientific temper.
3. To foster integrative medicine through mindful lifestyle choices and guided practices
4. To promote the integration of scientific research with ancient wellness practices & techniques.

MODULE	DETAILS
1.	**Foundations of Health Well-being** Defining Health and Wellness, Dimensions of wellness Determinants of Health behavior, Health in everyday life Constitution of your body, Medical Anatomy of physical body Layers of your Body: Physical, Physiological, Psyche Yogic anatomy of Physiological and Psyche layers, Triguna system
2.	**Physical Wellbeing** Management of Ailments: Common, Acute, chronic Integrative medicines: Ayurveda, Naturopathy, Yoga etc. Preventive care for illness, Lifestyle, Dietary habits, Repair and Rejuvenation
3.	**Emotional Wellness** Types of Emotions, Symptoms of emotional wellness Studies on challenges of emotional wellness: Sleep, Stress, Resilience, eating habits, attention deficit, Digital fatigue, Communications etc. Emotions and physical wellness Understanding the trinity of senses, sense objects and emotions, Studies on breath regulation, Role of breath in emotions, Yogic methods to emotional wellness

4.	**Mental Wellness** What is Mental Wellness, Dimensions of mental Wellness Scientific studies on Mental disorder issues: Depression, anxiety, behavioural disorder, addiction, self-disconnection, suicidal thoughts etc. Mind-Body issues: Mental Wellness, Mental illness and Physical illness, Constitution of Mind – Manas, Buddhi, ahankara, Chitta, Consciousness Intelligence and Mental Wellness, Modifications of Mind Paths to Mental Wellness: Regulating Thoughts, Meditation tools and process - Pranayama, Pratyahara, Dharna, Dhyana, Mindfulness meditation, Chakra meditation, Sabdh(mantra) Meditation, spiritual engagements
5.	**Intellectual Wellness** Mind, Intelligence and Intellectual Wellness Aspects of Intellect, incapacitate Intellect, Examining Intellectual Wellness, Nurturing Intellectual Wellness
6.	**Spiritual Wellness** Yogic understanding of term 'spiritual' Relationship: Physical, Physiological, Psyche, Consciousness (Spiritual) Symptoms of spiritual wellness Studies on Spiritual wellness and Body Healing Practices for spiritual wellness: Prayers, Yoga and Meditation, spiritual engagements

Course Outcome:
Learner will be able to

1. Gain a comprehensive understanding of Holistic Health
2. Acquire essential knowledge to regulate thoughts and behavior.
3. Apply holistic health tools for emotional stability and healthy mind
4. Develop proficiency in applying cognitive faculty for intellectual pursuits
5. Acquire holistic wisdom for attaining inner peace in daily life

Text Books

1. Nature Cure for All: Natural Remedies for Health Disorders (Publisher: Nisargopachar Gramsudhar Trust, Pune)

2. Towards the Wellness of Body, Mind and Self – Conference Proceedings Editor - Dr. Jayanti Chavan (Publisher: Institute of Science and Religion, Navi Mumbai)

3. Ayurveda & Panchakarma – The Science of Healing and Rejuvenation by Dr. Sunil V. Joshi (Publisher: Motilal Banarsidass Publishing House, Delhi)

Reference books

1. Dr R Nagarathna and Dr H R Nagendra: Yoga for Promotion of Positive Health (Publisher: SVYP, Bangalore)

2. Text book of Kriya Yoga – The Cosmic Engineering of Life in the light of Medical Science by Yogacharyya Dr. Chanchal Roy Devsharmman
(Publisher: Motilal Banarsidass Publishing House, Delhi)

3. Yog – Its Philosophy and Practice by Swami Ramdev
(Publisher: Divya Prakashan, Haridwar)

Other Resources:

1. NPTEL Course: Adolescent Health And Well-Being: A Holistic Approach by Dr. Sumana Samanta, Dr. Parmeshwar Satpathy, IIT Kharagpur.
Weblink https://nptel.ac.in/courses/127105236

2. NPTEL Course: The Science of Happiness and Wellbeing by By Prof. Priyadarshi Patnaik, Prof. Manas K. Mandal from IIT Kharagpur.
Weblink https://onlinecourses.nptel.ac.in/noc23_hs06/preview

Course Type	Course Code	Course Name	Credits
LLC	LLC6013	Health and Wellness	02

Program Outcomes addressed:

1. PO6: The Engineer and The World
2. PO7: Ethics
3. PO11: Life-Long Learning

Course Objectives:

1. To advocate for the significance of Holistic wellness
2. To enhance all dimensions of wellness through the lens of scientific temper.
3. To foster integrative medicine through mindful lifestyle choices and guided practices
4. To promote the integration of scientific research with ancient wellness practices & techniques.

MODULE	DETAILS
1.	**Foundations of Health Well-being** Defining Health and Wellness, Dimensions of wellness Determinants of Health behavior, Health in everyday life Constitution of your body, Medical Anatomy of physical body Layers of your Body: Physical, Physiological, Psyche Yogic anatomy of Physiological and Psyche layers, Triguna system
2.	**Physical Wellbeing** Management of Ailments: Common, Acute, chronic Integrative medicines: Ayurveda, Naturopathy, Yoga etc. Preventive care for illness, Lifestyle, Dietary habits, Repair and Rejuvenation
3.	**Emotional Wellness** Types of Emotions, Symptoms of emotional wellness Studies on challenges of emotional wellness: Sleep, Stress, Resilience, eating habits, attention deficit, Digital fatigue, Communications etc. Emotions and physical wellness Understanding the trinity of senses, sense objects and emotions, Studies on breath regulation, Role of breath in emotions, Yogic methods to emotional wellness

4.	**Mental Wellness** What is Mental Wellness, Dimensions of mental Wellness Scientific studies on Mental disorder issues: Depression, anxiety, behavioural disorder, addiction, self-disconnection, suicidal thoughts etc. Mind-Body issues: Mental Wellness, Mental illness and Physical illness, Constitution of Mind – Manas, Buddhi, ahankara, Chitta, Consciousness Intelligence and Mental Wellness, Modifications of Mind Paths to Mental Wellness: Regulating Thoughts, Meditation tools and process - Pranayama, Pratyahara, Dharna, Dhyana, Mindfulness meditation, Chakra meditation, Sabdh(mantra) Meditation, spiritual engagements
5.	**Intellectual Wellness** Mind, Intelligence and Intellectual Wellness Aspects of Intellect, incapacitate Intellect, Examining Intellectual Wellness, Nurturing Intellectual Wellness
6.	**Spiritual Wellness** Yogic understanding of term 'spiritual' Relationship: Physical, Physiological, Psyche, Consciousness (Spiritual) Symptoms of spiritual wellness Studies on Spiritual wellness and Body Healing Practices for spiritual wellness: Prayers, Yoga and Meditation, spiritual engagements

Course Outcome:
Learner will be able to

1. Gain a comprehensive understanding of Holistic Health
2. Acquire essential knowledge to regulate thoughts and behavior.
3. Apply holistic health tools for emotional stability and healthy mind
4. Develop proficiency in applying cognitive faculty for intellectual pursuits
5. Acquire holistic wisdom for attaining inner peace in daily life

Text Books

1. Nature Cure for All: Natural Remedies for Health Disorders (Publisher: Nisargopachar Gramsudhar Trust, Pune)

2. Towards the Wellness of Body, Mind and Self – Conference Proceedings Editor - Dr. Jayanti Chavan (Publisher: Institute of Science and Religion, Navi Mumbai)

3. Ayurveda & Panchakarma – The Science of Healing and Rejuvenation by Dr. Sunil V. Joshi (Publisher: Motilal Banarsidass Publishing House, Delhi)

Reference books

1. Dr R Nagarathna and Dr H R Nagendra: Yoga for Promotion of Positive Health (Publisher: SVYP, Bangalore)

2. Text book of Kriya Yoga – The Cosmic Engineering of Life in the light of Medical Science by Yogacharyya Dr. Chanchal Roy Devsharmman
(Publisher: Motilal Banarsidass Publishing House, Delhi)

3. Yog – Its Philosophy and Practice by Swami Ramdev
(Publisher: Divya Prakashan, Haridwar)

Other Resources:

1. NPTEL Course: Adolescent Health And Well-Being: A Holistic Approach by Dr. Sumana Samanta, Dr. Parmeshwar Satpathy, IIT Kharagpur.
Weblink https://nptel.ac.in/courses/127105236

2. NPTEL Course: The Science of Happiness and Wellbeing by By Prof. Priyadarshi Patnaik, Prof. Manas K. Mandal from IIT Kharagpur.
Weblink https://onlinecourses.nptel.ac.in/noc23_hs06/preview

Course Type	Course Code	Course Name	Credits
LLC	LLC6014	DIET AND NUTRITION	02

Program Outcomes addressed:

1. PO6 : The Engineer & Society
2. PO7 : Ethics
3. PO11: Life-long learning

Course Objectives :

1. To provide students with a comprehensive understanding of nutrition principles and their application in promoting optimal health.
2. To develop critical thinking skills to evaluate nutritional information and make informed decisions.
3. To apply knowledge of nutrition education and counselling to promote healthy nutrition practices in individuals and group.
4. To demonstrate an understanding of role of nutrition in disease prevention and management.

Module	Details
01.	**Nutrition for wellness -1** Introduction to nutrition, food pyramid, Macros: Carbohydrates, Protein and fats, Micros: Vitamins A C E K and D, Minerals-Calcium, Iron and Zinc Importance of hydration, signs and symptoms, stages of dehydration.
02.	**Nutrition wellness -2** Introduction to mindful eating, plate concept, understanding physical and emotional hunger, eating disorder-Anorexia nervosa, bulimia nervosa and binge eating.
03.	**Exercise and fitness** Introduction to exercise and its importance, types of exercise its classification, side effects of over exercising, Impact of sedentary lifestyle on body composition.
04.	**Sleep and relaxation** Flow of circadian rhythm, sleep cycle, stages of sleep, sides effects, sleeping disorder- sleep apnea, insomnia, sleep hygiene routine and foods inducing sleep
05.	**Managing stress** Introduction to stress, causes, effects of stress, management of stress, foods and adaptogenic foods for stress management.
06.	**The lifestyle flow** Morning/ wake up rituals, meal flow i.e in which order to eat, post meal flow, bedtime rituals – how should your last hour of the day look like
Total no. of hours: **30**	

Course Outcomes :

1. Understand the fundamentals of nutrition and its role in promoting wellness.
2. Apply mindful eating practices to manage physical and emotional hunger.
3. Assess the importance of exercise and its impact on health and fitness
4. Gain insights into sleep hygiene and manage sleep-related disorders.
5. Develop strategies for stress management using nutrition and adaptogenic foods.
6. Assess the importance of exercise and its impact on health and fitness

Text Books :

1. Nutrition and dietetics by C.S. shah: covers various aspects of nutrition, including nutrient metabolism, dietary planning and diet therapy.
2. Dietetics by B. Srilakshmi- covers aspects of dietetics including nutrition, food science and diet therapy.

Reference Books :

1. Nutrition science by B. Shrilakshmi: provides an overview of nutrition, nutrient metabolism and dietary patterns
2. Food science by B. Shrilakshmi covers food, including food composition, food processing and food safety.

Course Type	Course Code	Course Name	Credits
LLC	LLC6015	PERSONALITY DEVELOPMENT	02

Program Outcomes addressed:

1. PO6 : The Engineer & Society
2. PO7 : Ethics
3. PO11: Life-long learning

Course Objectives :

1. To enhance self-awareness and self-confidence in the students.
2. To develop effective communication, leadership, and interpersonal skills.
3. To equip students with stress management and time management techniques.
4. To foster teamwork, problem-solving, and decision-making abilities.
5. To prepare students for professional life through resume building, interview skills, and networking.
6. To instill a growth mindset and adaptability in personal and professional contexts.

Module	Details
01.	**Self-Awareness and Emotional Intelligence** Understanding personality traits and self-assessment, Importance of emotional intelligence (EI) in personal and professional success, Strategies to enhance EI and self-awareness.
02.	**Communication Skills** Fundamentals of verbal and non-verbal communication, Public speaking, presentation skills, and storytelling, Listening skills and constructive feedback.
03.	**Leadership and Teamwork** Understanding importance of self-confidence, leadership styles, and their applications, Building effective teams and managing conflicts, Developing collaboration and networking skills.
04.	**Stress and Time Management** Recognizing stressors and managing stress effectively, Prioritization and goal-setting techniques, Tools for efficient time management and productivity.
05.	**Professional Development** Importance of presentation skills, resume writing, cover letter, and LinkedIn optimization, Interview preparation: Mock interviews and common questions, Networking skills and professional etiquette
06.	**Personal Growth and Adaptability** Developing a growth mindset and embracing lifelong learning, Cultivating resilience and adaptability to change, Setting long-term personal and professional goals
Total no. of hours: **30**	

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

1. Demonstrate increased self-awareness and emotional intelligence.
2. Communicate effectively in professional and personal contexts.
3. Exhibit leadership and teamwork skills in various scenarios.
4. Manage time and stress efficiently to enhance productivity.
5. Prepare a professional resume, excel in interviews, and network effectively.
6. Develop resilience, adaptability, and a growth-oriented mind-set.

Text Books :

1. Daniel Goleman, Emotional Intelligence: Why It Can Matter More Than IQ / What Makes a Leader: Why Emotional Intelligence Matters
2. Stephen R. Covey, The 7 Habits of Highly Effective People: Powerful Lessons in Personal Change

Reference Books :

1. Dale Carnegie, How to Win Friends and Influence People.
2. Anthony Robbins, Awaken the Giant Within: How to Take Immediate Control of Your Mental, Emotional, Physical, and Financial Destiny!
3. David J. Schwartz, The Magic of Thinking Big.
4. Robin Sharma, The Monk who sold his Ferrari.
5. Dorie Clark, Reinventing You: Define Your Brand, Imagine Your Future.
6. Gangadhar Joshi, Campus to Corporate: Your Roadmap to Employability.

Other Resources :

1. Videos and TED Talks by Simon Sinek, Brené Brown, Malcolm Gladwell and other motivational speakers
2. Online courses on communication and leadership (e.g., Coursera, LinkedIn Learning, EdX).