DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Course Book for

B. Tech. in Electronics and Communication Engineering

For
NEP Batch
Students admitted in July 2022 onwards
[Incorporated all updates approved in the 75th Senate Meeting, VNIT Nagpur]

Visvesvaraya National Institute of Technology,

Nagpur-440 010 (M.S.)

Institute Vision Statement

To contribute effectively to the national and international endeavour of producing quality human resource of world class standard by developing a sustainable technical education system to meet the changing technological needs of the country and the world incorporating relevant social concerns and to build an environment to create and propagate innovative technologies for the economic development of the Nation.

Institute Mission Statement

The mission of VNIT is to achieve high standards of excellence in generating and propagating knowledge in science, engineering and allied disciplines. VNIT is committed to providing an education that combines rigorous academics with joy of discovery. The Institute encourages its community to engage in a dialogue with society to be able to effectively contribute for the betterment of humankind.

Department Vision Statement

The Department endeavors to facilitate state of the art technical education in the field of Electronics and Communication Engineering by infusing scientific temper in the students leading towards research and to grow as centre of excellence in the field. The vision of the department is to provide education to students that is directly applicable to problems and situations encountered in real life and thus foster a successful career. The department aims to provide the best platform to students and staff for their growth

Department Mission Statement

1. To be the epitome of academic rigour, flexible to accommodate every student and faculty for basic, current and future technologies in Electronics and Communication Engineering.
2. Strengthening and providing support in sustaining a healthy society by improving the quality of life through the application of technology.

Brief about Electronics and Communication Engineering Department

The Electronics and Communication Engineering (ECE) Department department started with an intake of 30 in 1984. Subsequently, the intake increased progressively, and the current intake for the UG program of B.Tech ECE is 125, and that of the PG program, namely M.Tech in Communication System Engineering, is 25. The department also offers PhD and Post-Doctoral programs. The department remains the most sought after within the first two choices. The department has a good number of highly qualified and experienced faculties. The average experience of the faculty is 15 years, and the Professors have experience of 25 to 35 years. The department has produced GATE/CAT toppers for various years and Institute Visvesvaraya Medalists for many years. The alumni are highly placed, with 5% being entrepreneurs. The IPR of the department is very good in terms of faculty research publications with high citations in Google Scholar and SCI-indexed Journals and granted patents. There are always a good number of externally funded or sponsored research projects ongoing. The department has a very active and fruitful institute-industry interaction.

The department has the following centers of excellence:

1. Center of Excellence in Embedded Systems established with grants from World Bank TEQIP funds. The center continues to train aspiring students with evening training programs.
2. Center of Excellence of AI
3. 5G LAB Center
4. Center of Excellence of EMC-EMI.

The department works in upcoming and niche areas of electronics and communication engineering like 5G/6G, RF and Antennas, Signal Processing, AI/ML, Optoelectronics and Photonics, IoT, Automotive Electronics, Sensors and Instrumentation, Microelectronics, Biomedical Signal and Image Processing, Image Processing and Pattern Recognition. The department lays emphasis on clear fundamental concepts and applications of engineering through mini and major projects and internships. It is based on NEP 2020 and is accommodating for slow as well as fast learners. The annual external academic audit is a quality control exercise to keep abreast with technology and academic standards. Both the UG and PG programs are accredited for six years. The labs in the department have the latest equipment and students are made fully conversant with it with a considerable hands-on component. On the consultancy front, the department is growing now. The synergy of the department is very high. The department also offers two online PG program namely "M.Tech in Applied AI" and "M.Tech. in Applied AI and Communications" for working professionals. We are very confident that our students will excel in their performance wherever they go.

List of Faculty Members ECE Deptartment

S. No.	Faculty Name	Areas of Specialization
1.	Dr. A. S. Gandhi	Wireless communication, RF circuits and systems, Computer networks
2.	Dr. K. M. Bhurchandi	Embedded Systems, Image Processing
3.	Dr. Ashwin Kothari	Communication, Signal processing, Rough Sets, Cognitive Radio, Reconfigurable Antennas, COMMBEDDED Systems: Hybridization of Communication and Embedded Systems.
4.	Dr. V. R. Satpute	Image Processing, Computer Vision, Signal Processing, Cryptography, Bio-metrics.
5.	Dr. Prabhat Sharma	Wireless and Molecular Communications, Evolutionary Algorithms, Signal Processing and Machine Learning for Communications.
6.	Dr. Saugata Sinha	Image Processing, Pattern Recognition, Medical Imaging. Signal Processing.
7.	Dr. Deep Gupta	Medical Imaging, Signal & Image Processing, Ultrasound, Medical Image Processing and Analysis, Multimedia application
8.	Dr. P. H. Ghare	Body Area Networks, Wireless Sensors Network, Analog Circuit Design
9.	Dr. J. Sengputa	Communication & Microwave
10.	Dr. Neeraj Rao	Antennas and Microwave
11.	Dr. Ankit Bhurane	Signal Processing, Video and Image Processing, Machine Learning
12.	Dr. K. Surender	Control and Instrumentation
13.	Dr. Punitkumar Bhavsar	Cyber-Physical Systems, Control Engineering
14.	Dr. Anamika Singh	Photonic Integrated Circuits, Optoelectronics
15.	Dr. Praveen Pawar	Wireless Communications, IoT, 5G/6G technologies, Data Analytics, Optimization
16.	Dr. Amit Agrawal	Wireless Communication, Free-space Optics
17.	Dr. Arvind Kumar	Antennas, Microwave and mmWave Communication
18.	Dr. Vipin Kamble	Signal, Image and Video Processing

UG/ PG Programs Offered by ECE Department:

The department offers following undergraduate and postgraduate programs

	Program	Description	Remark
UG	B.Tech. in Electronics and Communication Engineering	Intake: 116	NEP provisions for 1. B.Tech. ECE with Minor (in specified field with additional credits of 16-18) 2. Academic bank of credits 3. Early exit with certificate/diploma under special circumstances*
PG	M.Tech. in Communication System Engineering	Intake: 23	
PG	M.Tech in Applied AI (Online)	Intake: 100	
PG	M.Tech in Applied AI And Communications (Online)	Intake: 100	

*Please refer academic rule book for details.

Credit System at VNIT

Education at the Institute is organized around the semester-based credit system of study. The prominent features of the credit system are a process of continuous evaluation of a student's performance / progress and flexibility to allow a student to progress at an optimum pace suited to his/her ability or convenience, subject to fulfilling minimum requirements for continuation. A student's performance/progress is measured by the number of credits he/she has earned, i.e. completed satisfactorily. Based on the course credits and grades obtained by the student, grade point average is calculated. A minimum number of credits and a minimum grade point average must be acquired by a student in order to qualify for the degree.

Course Credits Assignment

Each course, except a few special courses, has certain number of credits assigned to it depending on lecture, tutorial and laboratory contact hours in a week.

For Lectures and Tutorials: One lecture hour per week per semester is assigned one credit and

For Practical/ Laboratory/ Studio: One hour per week per semester is assigned half credit.

Example: Course XXXXXX with (3-0-2) as (L-T-P) structure, i.e., 3 hr Lectures + 0 hr Tutorial + 2 hr Practical per week, will have (3x1 + 0x1 + 2x0.5 =) 4 credits.

Grading System

The grading reflects a student's own proficiency in the course. While relative standing of the student is clearly indicated by his/her grades, the process of awarding grades is based on

fitting performance of the class to some statistical distribution. The course coordinator and associated faculty members for a course formulate appropriate procedure to award grades. These grades are reflective of the student's performance vis-à-vis instructor's expectation. If a student is declared pass in a subject, then he/she gets the credits associated with that subject.

Depending on marks scored in a subject, a student is given a Grade. Each grade has got certain grade points as follows:

Grade	Grade points	Description
AA	10	Outstanding
AB	9	Excellent
BB	8	Very good
BC	7	Good
CC	6	Average
CD	5	Below average
DD	4	Marginal (Pass Grade)
FF	0	Poor (Fail) /Unsatisfactory / Absence from end-sem exam
NP	-	Audit pass
NF	-	Audit fail
SS	-	Satisfactory performance in zero credit core course
ZZ	-	Unsatisfactory performance in zero credit core course
W	-	Insufficient attendance

Performance Evaluation

The performance of a student is evaluated in terms of two indices, viz, the Semester Grade Point Average (SGPA) which is the Grade Point Average for a semester and Cumulative Grade Point Average (CGPA) which is the Grade Point Average for all the completed semesters at any point in time. CGPA is rounded up to second decimal.

The Earned Credits (ECR) are defined as the sum of course credits for courses in which students have been awarded grades between AA to DD. Grades obtained in the audit courses are not counted for computation of grade point average.

Earned Grade Points in a semester (EGP) = **Σ** (Course credits x Grade point) for courses in which AA- DD grade has been obtained.

SGPA = EGP / Σ (Course credits) for courses registered in a semester in which AA-FF grades are awarded.

CGPA= EGP / Σ(Course credits) for courses passed in all completed semesters in which AA- DD grades are awarded.

Attendance Rules

1. All students must attend every class and 100% attendance is expected from the students. However, in consideration of the constraints/ unavoidable circumstances, the attendance can be relaxed by course coordinator only to the extent of not more than

25%. Every student must attend minimum of 75% of the classes actually held for that course.

2. A student with less than 75% attendance in a course during the semester will be awarded W grade. Such a student will not be eligible to appear for the end semester and re-examination of that course. Even if such a student happens to appear for these examinations, then, answer books of such students will not be evaluated.
3. A student with W grade is not eligible to appear for end semester examination, reexamination & summer term.

Program Outcomes (Department Specific) for B. Tech in ECE

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

Program Specific Outcomes (Department Specific) for B. Tech in Electronics and Communication Engineering

1. To comprehend and analyze the concepts and state of the art applications in the field of broadband and wireless communication, embedded systems, signal processing, electronics systems design & VLSI.
2. To be able to analyze, design, implement and test different systems which conform to given specifications for various fields of electronics and communication engineering.
3. To be able to develop the solutions of the real-world problems in the various fields of electronics, and communication engineering with a responsible view towards upcoming societal and environmental needs.

Courses to Register in First Year B. Tech.

I Semester						
CORE						
S. No	**Code**	**Course Title/ Name**	**Type**	**L-T-P**	**Credits**	**Page No.**
		Please refer Scheme of Basic Sciences				--

II Semester						
CORE						
S. No	**Code**	**Course Title/ Name**	**Type**	**L-T-P**	**Credits**	**Page No.**
		Please refer Scheme of Basic Sciences				--

B. Tech. in Electronics and Communication Engineering Scheme 2nd year Onwards

Overall Credits Requirement for Award of Degree

With one year (VII and VIII Semester) internship

Sr. No	Type	III Sem	IV Sem	V Sem	VI Sem	VII Sem	VIII Sem	Total Requirement
1	DC	26	27	20	0	3	3	79 (Fixed)
2	DE/OC/HM	3	3	6-8	24-26	3-11	11-3	48-50
	Total (per sem)	29	30	26-28	24-26	6-14	14-6	127-129
First Year Credit = 43; Total Min Credit = 170; Total Max Credit = 172 Min Credit Required to be Earned = 170-43 = 127; Max Credit Required to be Earned = 172 - 43 = 129								

***Range is indicative. Students must ensure fulfillment of credit requirements as per the courses offered by the department and the number of students allowed in any elective subjects**

With one semester (either VII or VIII) internship

Sr. No	Type	III Sem	IV Sem	V Sem	VI Sem	VII Sem	VIII Sem	Total Requirement
1	DC	26	27	20	0	3	3	79 (Fixed)
2	DE/OC/HM	0	0	3-4	20-24	3-17	22-3	48-50
	Total (per sem)	26	27	23-24	20-24	6-20	25-6	127-129
First Year Credit = 43; Total Min Credit = 170; Total Max Credit = 172 Min Credit Required to be Earned = 170-43 = 127; Max Credit Required to be Earned = 172 - 43 = 129								

***Range is indicative. Students must ensure fulfillment of credit requirements as per the courses offered by the department and the number of students allowed in any elective subjects**

Without internship

Sr. No	Type	III Sem	IV Sem	V Sem	VI Sem	VII Sem	VIII Sem	Total Requirement
1	DC	26	27	20	0	3	3	79 (Fixed)
2	DE/OC/HM	0	0	3-4	20-24	6-20	20-0	48-50
	Total (per sem)	26	27	23-24	20-24	9-23	23-3	127-129
First Year Credit = 43; Total Min Credit = 170; Total Max Credit = 172 Min Credit Required to be Earned = 170-43 = 127; Max Credit Required to be Earned = 172 - 43 = 129								

***Range is indicative. Students must ensure fulfillment of credit requirements as per the courses offered by the department and the number of students allowed in any elective subjects**

Courses to Register in Second Year B. Tech.

III Semester						
S. No	**Code**	**Course Title/ Name**	**Type**	**L-T-P**	**Credits**	**Page No.**
1	MAL205	Probability Theory and Numerical Methods	DC	3-1-0	4	18
2	EEL209	Linear Network Theory	DC	3-0-0	3	20
3	ECL257	Electronic Circuits	DC	3-1-0	4	21
4	ECP257	Electronic Circuits	DC	0-0-2	1	22
5	ECL211	Signals and Systems Analysis	DC	3-1-0	4	23
6	ECP211	Signals and Systems Analysis	DC	0-0-2	1	25
7	ECL204	Measurements and Instrumentation	DC	3-0-0	3	26
8	ECP204	Measurements and Instrumentation	DC	0-0-2	1	28
9	ECL216	Digital Circuits and Hardware Design	DC	3-1-0	4	29
10	ECP216	Digital Circuits and Hardware Design	DC	0-0-2	1	30
ELECTIVE* (Students must ensure fulfillment of credit requirements as per the courses offered by the department and the number of students allowed in any elective subjects.)						
1	OC	OC	OC	3-0-0	3	-
2	HM	HM	HM	3-0-0	3	-
3	DE	DE	DE	3-0-0	3	-
For one year internship		**Total No. of Credits (26 + 3)**			**29**	
For one semester internship (either VII or VIII semester) /(OR) without internship in final year		**Total No. of Credits (26 + 0)**			**26**	

IV Semester						
S. No	**Code**	**Course Title/ Name**	**Type**	**L-T-P**	**Credits**	**Page No.**
1	MAL210	Linear Algebra and Partial Differential Equations	DC	3-1-0	4	31
2	ECL304	Digital Signal Processing	DC	3-0-0	3	32
3	ECP304	Digital Signal Processing	DC	0-0-2	1	33
4	ECL305	Electromagnetic Fields	DC	3-1-0	4	34
5	ECL315	Microprocessors and Microcontrollers	DC	3-0-0	3	35

6	ECP315	Microprocessors and Microcontrollers	DC	0-0-2	1	36
7	ECL301	Analog Communication	DC	3-1-0	4	37
8	ECP301	Analog Communication	DC	0-0-2	1	38
9	ECP307	Electronic Product Engineering Workshop	DC	0-0-2	1	41
10	ECL308	Analog Circuit Design	DC	3-1-0	4	42
11	ECP308	Analog Circuit Design	DC	0-0-2	1	43
ELECTIVE* (Students must ensure fulfillment of credit requirements as per the courses offered by the department and the number of students allowed in any elective subjects.)						
1	OC	OC	OC	3-0-0	3	-
2	HM	HM	HM	3-0-0	3	-
3	DE	DE	DE	3-0-0	3	-
For one year internship		**Total No. of Credits (27+3)**			**30**	
For one semester internship (either VII or VIII semester) / without internship in final year		**Total No. of Credits (27+0)**			**27**	

Courses to Register in Third Year B. Tech.

V Semester						
S. No	**Code**	**Course Title/ Name**	**Type**	**L-T-P**	**Credits**	**Page No.**
1	ECL312	Control Engineering	DC	3-0-0	3	44
2	ECP312	Control Engineering	DC	0-0-2	1	45
3	ECL303	Digital Communication	DC	3-1-0	4	46
4	ECP303	Digital Communication	DC	0-0-2	1	48
5	ECL404	RF and Microwave Engineering	DC	3-0-0	3	50
6	ECP404	RF and Microwave Engineering	DC	0-0-2	1	51
7	ECL317	Integrated Circuit Design	DC	3-0-0	3	52
8	ECP317	Integrated Circuit Design	DC	0-0-2	1	53
9	ECL405	Waveguides and Antennas	DC	3-0-0	3	54
ELECTIVE* (Students must ensure fulfillment of credit requirements as per the courses offered by the department and the number of students allowed in any elective subjects.)						
1	OC	OC	OC	3-0-0	3	-
2	HM	HM	HM	3-0-0	3	-

3	DE	DE	DE	3-0-0	3	-
4	DE	DE	DE	3-0-2	4	-
For one year internship		**Total No. of Credits (20 + 6 to 8)**			**26 to 28**	
For one semester internship (either VII or VIII semester) / without internship in final year		**Total No. of Credits (20 + 3 to 4)**			**23 to 24**	

VI Semester						
S. No	**Code**	**Course Title/ Name**	**Type**	**L-T-P**	**Credits**	**Page No.**
1	ECD403	Project Course (ECD type)	AU	0-0-4	0	55
ELECTIVE* (Students must ensure fulfillment of credit requirements as per the courses offered by the department and the number of students allowed in any elective subjects)						
1	OC	OC	DE	3-0-0	3	-
2	HM	HM	DE	3-0-0	3	-
3	DE	DE	DE	3-0-0	3	-
4	DE	DE	DE	3-0-2	4	-
For one year internship		**Total No. of Credits (0 + 24 to 26)**			**24 to 26**	**-**
For one semester internship (either VII or VIII semester) / without internship in final year		**Total No. of Credits (0 + 20 to 24)**			**20 to 24**	

Courses to Register in Fourth Year B. Tech.

VII Semester						
S. No	**Code**	**Course Title/ Name**	**Type**	**L-T-P**	**Credits**	**Page No.**
1	ECD401	Project Phase I	DC	0-0-4	3	56
ELECTIVE*(Students must ensure fulfillment of credit requirements as per the courses offered by the department and the number of students allowed in any elective subjects)						

VIII Semester						
S. No	**Code**	**Course Title/ Name**	**Type**	**L-T-P**	**Credits**	**Page No.**
1	ECD402	Project Phase II	DC	0-0-8	3	57
ELECTIVE* (Students must ensure fulfillment of credit requirements as per the courses offered by the department and the number of students allowed in any elective subjects)						

Note:

1. **For one year (VII and VIII Semester) internship, student should opt 01 to 02 MOOC courses (3 credits each)/Independent Studies Course (2 credit) from the elective basket to complete the credit requirement (170-172 credits) for B.Tech. degree.**
2. **For one semester (either VII or VIII) internship, student should complete the remaining credits (20 to 25) in final year from the elective basket to complete the credit requirement (170-172 credits) for B.Tech. degree.**
3. **For without internship, student should complete the remaining credits (20 to 25) in final year from the elective basket to complete the minimum credit requirement (170-172 credits) for B.Tech. degree.**
4. ***Pre-requisite: Course prerequisite indicates that a student is expected to have undergone that course (without W grade) in the past. However, a student who has not completed the prerequisite course(s) but is willing to study contents of the prerequisite course without the teacher's support to understand the course opted, may register for the course in question.**

Elective Basket

S. No.	Code	Course Title/ Name	Type	L-T-P	Credits	Page No.
1	CSL311	Computer Architecture & Organization	DE	3-0-0	3	58
2	ECL411	Digital Image Processing	DE	3-0-2	4	59
3	ECL412	Advanced Digital Signal Processing	DE	3-0-2	4	61
4	ECL408	Biomedical Engineering	DE	3-0-0	3	62
5	ECL311	Automotive Electronics	DE	3-0-0	3	63
6	ECL414	Electronic Product Design and Reliability	DE	3-0-0	3	64
7	ECL307	Statistical Signal Processing	DE	3-0-0	3	65
8	CSL312	Concepts in Operating Systems	DE	3-0-0	3	66
9	ECL420	Smart Antennas	DE	3-0-0	3	67
10	ECL429	Communication Networks	DE	3-0-2	4	68
11	ECL430	Biomedical Signal Processing	DE	3-0-2	4	70
12	ECL443	Machine Learning with Python	DE	3-0-2	4	72
13	ECL423	Image Analysis and Computer Vision	DE	3-0-2	4	74
14	ECL413	Adaptive Signal Processing	DE	3-0-2	4	78
15	ECL439	Wireless Communication	DE	3-0-0	3	79
16	ECL437	Fundamentals of Information Theory	DE	3-0-0	3	80
17	ECL424	Optical Communication	DE	3-0-2	4	81

18	ECL314	Power Electronic Devices and Circuits	DE	3-0-0	3	82
19	ECL407	Radar Engineering	DE	3-0-0	3	83
20	ECL410	Satellite Communication	DE	3-0-0	3	84
21	ECL436	Optimal Systems	DE	3-0-0	3	85
22	ECL421	Advanced Sensors and Instrumentation	DE	3-0-0	3	86
23	MAL408	Statistical Analysis & Queuing Theory	DE	3-0-0	3	87
24	ECL440	Cellular Systems	DE	3-0-0	3	88
25	ECL409	Radio Frequency Circuit Design	DE	3-0-0	3	89
26	ECP409	Radio Frequency Circuit Design	DE	0-0-2	1	90
27	ECL417	Multimedia Networks	DE	3-0-0	3	91
28	ECL418	Network Planning and Management	DE	3-0-0	3	92
29	ECL419	Wireless Sensor Networks	DE	3-0-2	4	93
30	ECL427	Broadband Communication	DE	3-0-0	3	94
31	ECL532	Wavelets and Multi-media Applications	DE	3-0-2	4	95
32	ECL4XX	Multivariate Statistical Analysis	DE	3-0-0	3	97
33	ECL4XX	Embedded Systems for IoT	DE	3-0-2	4	98
34	ECL4XX	Emerging Communication Technologies	DE	3-0-2	4	99
35	ECL5XX	Microwave Integrated Circuits and Systems	DE	3-0-2	4	101
36	ECL4XX	Medical Image Analysis	DE	3-0-0	3	103
37	ECL4XX	Quantum Computing and Quantum Communication	DE	3-0-0	3	104
38	ECL4XX	Industry Internship VII sem.	DE	0-0-6	3	105
39	ECL4XX	Industry Internship VIII sem.	DE	0-0-6	3	-
40	IDL4XX	MOOC1	DE	3-0-0	3	-
41	IDL4XX	MOOC2	DE	3-0-0	3	-
42	IDL4XX	MOOC3	DE	3-0-0	3	-
43	ECL4XX	Independent Studies	DE	0-2-0	2	-

Minor Course: Internet of Things

Sr. No.	Course Code	Course Name	Structure L-T-P-Cr	Semester	*Pre-requisite(s) and /or any other condition for registration		Page No.
					Course Code	Course Name	
1	ECL217	Concepts of Communication	3-0-2-4	3	None	None	107
2	ECL316	Communication Networks for IoT	3-0-2-4	4	ECL217	Concepts of Communication	108
3	ECL441	IoT Design	3-0-2-4	5	ECL217 ECL316	Concepts of Communication Communication Networks for IoT	109
4	ECD404	IoT based Mini Project	0-0-8-4	6	ECL217 ECL316 ECL441	Concepts of Communication Communication Networks for IoT IoT Design	109
Total Credits			**16**				

MAL205 Probability Theory and Numerical Methods [(3-1-0); Credits: 4]

Course Outcomes (COs):

Upon completion of this course, the students will be able to:

1. Employ a number of techniques to solve transcendental and algebraic equations. Know how to solve a system of nonlinear equations by Newton-Raphson method.
2. Efficiently solve a system of linear equations and find their eigenvalues and eigenvectors. Design and implement numerical methods for numerical approximation of initial value problems as well as two-point boundary value problems.
3. Apply the concepts such as random variables, probability density function, cumulative distribution function, and joint probability density function in the engineering and science problems.
4. Analyze and apply the concepts such as mathematical expectation, functions of random variables, variance, standard deviations, moment generating function, Skewness and Kurtosis.
5. Exploit different probability distributions such as Binomial, Geometric distribution, Poisson distribution, and normal distribution in the engineering and science problems.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	2	-	-	-	-	-	-	-	1	1	-	-
CO2	3	3	1	3	-	-	-	-	-	-	-	1	-	1	-
CO3	3	3	1	3	-	-	-	-	-	-	-	1	-	1	-
CO4	3	3	1	2	-	-	-	-	-	-	-	1	-	1	-
CO5	3	3	2	3	-	-	-	-	-	-	-	2	2	1	-

Content:

Numerical Analysis: Solutions of algebraic and transcendental equations by Iteration method, method of false position, Newton-Raphson method and their convergence.

Solutions of system of linear equations by Gauss elimination method, Gauss Seidal method, LU decomposition method. Newton-Raphson method for system of nonlinear equations.

Eigen values and eigen vectors: Power and Jacobi methods.

Numerical solution of ordinary differential equations: Taylor's series method, Euler's modified method, Runge-Kutta method, Adam's Bashforth and Adam's Moulton, Milne's predictor corrector method. Boundary value problems: Shooting method, finite difference methods.

Probability theory:

Random variables, discrete and continuous random variable, probability density function; probability distribution function for discrete and continuous random variable joint distributions.

Definition of mathematical expectation, functions of random variables, The variance and standard deviations, moment generating function other measures of central tendency and dispersion, Skewness and Kurtosis.

Binomial, Geometric distribution, Poisson distribution, Relation between Binomial and Poisson's distribution, Normal distribution, Relation between Binomial and Normal distribution. Introduction to Stochastic Processes.

Textbooks / Reference Books:

1. Jain, Iyengar and Jain: Numerical Methods for Engineers and Scientists, WileyEastern

2. V.K. Rohatgi and A.K.M. Ehsane: An Introduction to Probabability and Statistics, John Wiley & Sons
3. S. D. Cante and C. de Boor, “Elementary Numerical Analysis, an algorithmic approach”, McGraw-Hill.
4. Gerald and Wheatley: “Applied Numerical Analysis”, Addison-Wesley.
5. Spiegel, M.R.; “Theory and problems of Probability and statistics”; McGraw-HillBookCompany; 1980.
6. K.S. Trivedi: “Probability Statistics with Reliability, Queuing and Computer Science applications”, Prentice Hall ofIndia Pvt. Ltd.

EEL209 Linear Network Theory [(3-0-0); Credits: 3]

Course Outcomes

1. Understand basics electrical circuits with nodal and mesh analysis.
2. Appreciate electrical network theorems.
3. Apply Laplace Transform for steady state and transient analysis.
4. Determine different network functions.
5. Appreciate the frequency domain techniques.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	3	1	1	-	-	-	-	-	-	1	3	-	-
CO2	2	2	2	1	1	-	-	-	-	-	-	1	3	-	-
CO3	2	2	2	1	-	-	-	-	-	-	-	1	2	2	-
CO4	2	2	2	2	-	-	-	-	-	-	-	1	2	3	2
CO5	2	2	2	3	1	1	-	-	-	-	-	1	2	-	-

Contents:

Node and Mesh Analysis: Node and mesh equation, matrix approach of complicated network containing voltage and current sources, and reactances, source transformation and duality. Network theorem: Superposition, reciprocity, Thevenin's, Norton's, Maximum power Transfer, compensation and Tallegen's theorem as applied to AC. circuits. Trigonometric and exponential Fourier series: Discrete spectra and symmetry of waveform, steady state response of a network to non-sinusoidal periodic inputs, power factor , effective values, Fourier transform and continuous spectra, three phase unbalance circuit and power calculation.

Laplace transforms and properties: Partial fraction, singularity functions, waveform synthesis, analysis of RC, RL, and RLC networks with and without initial conditions with Laplace transforms evaluation of initial conditions. Two four port network and interconnections, Behaviors of series and parallel resonant circuits, Introduction to band pass, low pass, high pass and band reject filters.

Transient behavior, concept of complex frequency, Driving points and transfer functions poles and zeros of immittance function, their properties, sinusoidal response from pole-zero integral solutions. locations, convolution theorem and Two four port network and interconnections, Behaviors of series and parallel resonant circuits, Introduction to band pass, low pass, high pass and band reject filters.

Text/Reference Books

1. Van, Valkenburg.; Network analysis; Prentice hall of India, 2000
2. Sudhakar, A., Shyammohan, S. P.; Circuits and Network; Tata Mcgraw-Hill New Delhi, 1994

ECL257 Electronic Circuits: [(3-1-0); Credits: 4]

Course Outcomes

Students will

1. Examine the electronic properties of the semiconductor.
2. Analyze the electronic devices and their applications to circuits.
3. Design of amplifier for high power applications.
4. Illustrate and analyze the characteristics of MOS devices.
5. Examine small signal analysis of MOS devices.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	-	-	-	1	2	3	1
CO2	3	3	2	-	-	1	-	-	-	-	-	1	2	3	1
CO3	3	3	2	1	1	1	-	-	-	-	-	1	2	3	1
CO4	3	3	2	1	1	1	-	-	-	-	-	1	2	3	1
CO5	3	3	2	2	2	1	-	-	-	-	-	2	2	3	1

Course Content:

BJT: Small signal low frequency amplifier. UJT characteristics and applications.

Design of emitter follower regulator, series regulators, overload protection circuits for regulators

Power amplifiers: Class A, B, AB,C, Efficiency calculations, Push pull complementary symmetry, feedback circuits, Amplifier and Oscillators, Differential amplifier, configurations, DC and AC analysis, constant current bias, current mirror, cascaded differential amplifier stages, level translator.

Design of class A small signal amplifiers: Emitter follower, Darlington pair amplifiers with and without Bootstrapping, Two stage direct coupled amplifier. Design of class A, Class AB, audio power amplifier with drivers.

Field Effect Transistor and MOSFET: V-I characteristics, Biasing Arrangement, Small Signal Analysis of CG, CD & CS, High Frequency Analysis.

Books:

1. “Electronic Devices and Circuits”, Millman Halkias, TMH, 2000
2. “Electronic Devices and Circuits”, David A. Bell”, “PHI”, 4th Edition
3. “Microelectronics Circuits”, “Adel S. Sedra and Kenneth C. Smith”, “Oxford University Press” Eighth Edition
4. “Electronic devices and Circuit Theory”, “R. Boylestad”, “Pearson Education”, 9th Edition
5. “Electron devices”, “S. Poornachandra, Sasikala”, “Scitech”, 2nd Edition
6. “Foundation of Electronics Circuits and Devices”, “Meade”, “Thompson”, 4th Edition

ECP257: Electronic Circuits [(0-0-2); Credits: 1]
Course Outcomes:

Student will be:

1. Familiar with various components and devices such as Bipolar Junction Transistor, MOSFET and will also be familiar with Data sheets of various Devices.
2. Familiar with basic laboratory instruments such as DC Power supply, Function Generator, Multimeter, CRO, etc., and their handling.
3. Familiar with how to construct the circuit and procedure to test the circuit.
4. Understanding how to study V-I characteristics of various devices and the working principle of this devices.
5. Understanding the input and output characteristics of this devices and hence the application of this devices. To study and understand the devices in detail to use this devices for various application.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	1	-	2	-	-	1	2	3	-	1	2	3	1
CO2	3	3	3	-	3	-	-	1	2	3	-	1	2	3	1
CO3	3	3	3	-	3	-	-	1	2	3	-	1	2	3	1
CO4	3	-	1	-	2	-	-	1	2	3	-	1	2	3	1
CO5	3	3	3	-	3	-	-	1	2	3	-	1	2	3	1

List of Tentative Experiments:

1. Bipolar Junction Transistor Input Characteristics
2. Bipolar Junction Transistor Output Characteristics
3. Biasing and Stabilization of BJT Amplifier
4. Efficiency calculation for Power Amplifier
5. Single Stage BJT Amplifier
6. Emitter Follower Regulator
7. RC Phase Shift Oscillator (Low Frequency Application)
8. Junction Field Effect Transistor Characteristics
9. P MOS Characteristics
10. N MOS Characteristics
11. Breadboard based one mini project

(The project list and details will be updated time to time)

ECL211 Signals and System Analysis [(3-1-0); Credits: 4]

Course Outcomes

Students will be able to

1. Classify systems using properties and determine the response of the LTI system using convolution.
2. Analyse and synthesize spectral characteristics of continuous-time periodic and aperiodic signals.
3. Analyse system properties based on impulse response and Fourier analysis.
4. Interpret and relate the sampling process and the effects in the time and frequency domain.
5. Apply spectral tools to gain insights into continuous/ discrete-time signals and systems.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	-	-	-	-	-	-	-	1	3	1	1
CO2	3	3	2	2	-	-	-	-	-	-	-	1	2	2	2
CO3	3	3	2	2	-	-	-	-	-	-	-	1	2	2	2
CO4	3	2	3	3	-	-	-	-	-	-	-	1	2	2	1
CO5	3	3	2	2	-	-	-	-	-	-	-	1	2	2	1

Contents:

CONTINUOUS-TIME, AND DISCRETE-TIME SIGNALS AND SYSTEMS

Signals, Signal Energy and Power, Transformations of the Independent Variable, Periodic Signals, Even and Odd Signals, Exponential and Sinusoidal Signals, Complex Exponential and Sinusoidal Signals, Unit Impulse and Unit Step Functions, Systems and Properties

LINEAR TIME-INVARIANT SYSTEMS

LTI Systems: The Convolution Integral/ Sum, The Unit Impulse, The Representation of Signals in Terms of Impulses, The Unit Impulse Response, Representation of LTI Systems, Properties of LTI Systems.

CONTINUOUS AND DISCRETE-TIME FOURIER SERIES AND FOURIER TRANSFORM

The Response of LTI Systems to Complex Exponentials, Fourier Series Representation, Linear Combinations of Harmonically Related Complex Exponentials, Determination of the Fourier Series Representation, Convergence of the Fourier Series, Properties, Parseval's Relation. Representation of Aperiodic Signals: Fourier Transform, Convergence of Fourier Transforms, Properties.

TIME AND FREQUENCY CHARACTERIZATION OF SIGNALS AND SYSTEMS

The Magnitude-Phase Representation of the Fourier Transform, Frequency Response of LTI Systems, Linear and Nonlinear Phase, Group Delay.

SAMPLING

Introduction, Representation of a Continuous-Time Signal by Its Samples: The Sampling Theorem, Impulse-Train Sampling, Reconstruction of a Signal from Its Samples Using Interpolation, The Effect of Undersampling: Aliasing, Discrete-Time Processing of Continuous-Time Signals, Sampling of Discrete-Time Signals, Impulse-Train Sampling, Discrete-Time Decimation, and Interpolation.

THE LAPLACE AND Z-TRANSFORM

Region of Convergence, Inverse Laplace Transform, Geometric Evaluation of the Fourier Transform from the Pole-Zero Plot, Properties, Analysis, and Characterization of LTI Systems, Interconnections.

Text Book:

1. A.V. Oppenheim, A.S. Wilsky and H. Nawab S, “Signals & Systems”, Prentice-Hall, 2005.
2. Lathi, B. P., and R. A. Green. Linear Systems and Signals. 2018.

Reference Books:

1. Ashok Ambardar, “Introduction to Analog and Digital Signal Processing”, PWS Publishing Company, Newyork, 2002.
2. Rodger E Zaimer and William H Tranter, “Signals & Systems – Continuous and Discrete”, McMillan Publishing Company, Bangalore, 2005.
3. John .G.Proakis , “Digital Signal Processing Principles, Algorithms and Applications , Prentice Hall, New Delhi 2006,.
4. Sanjit .K. Mitra “Digital Signal Processing A Computer based approach” ‘Tata McGraw Hill Edition, New Delhi, 2001,
5. S. Haykin and Barry Van Veen, “Signals & Systems”, John Wiley and Sons Inc., New Delhi, 2008.

ECP211 Signals and Systems Analysis [(0-0-2); Credits: 1]

Course Outcomes:

1. To understand basic signals operations such as convolution, correlation, signal shifting
2. To understand linear system dynamics such as stability, time invariance and causality.
3. To compute DFT of a signal.
4. To understand and verify different properties of DFT.
5. To compute and apply Z transform of a signal.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	-	1	2	2	-	1	3	0	0
CO2	3	2	1	-	-	-	-	1	2	2	-	1	2	1	1
CO3	3	2	1	1	-	-	-	1	2	2	-	1	1	0	1
CO4	3	2	1	-	-	-	-	1	2	2	-	1	1	0	2
CO5	3	2	1	1	-	-	-	1	2	2	-	1	1	1	1

List of Experiments:

1. To demonstrate generation of some simple signals such as the complex exponential signal and real sinusoids.
2. To explore the commutation of even and odd symmetries in a signal with algebraic operations.
3. To explore the effect of transformation of signal parameters (amplitude-scaling, and time-shifting).
4. To explore the various properties of the impulse signals.
5. To verify different properties of a given system as linear or non-linear, causal or non-causal, stable or unstable etc.
6. To compute discrete Fourier transform of a signal.
7. Verification of Perceval's theorem associated with Fourier series analysis for a periodic square wave sampled using appropriate sampling frequency.
8. Verification of Multiplication property associated with Fourier series analysis for a periodic triangular wave sampled using appropriate sampling frequency.
9. Verification of shifting property associated with Fourier series analysis for a periodic square wave sampled using appropriate sampling frequency.
10. Verification of symmetry properties associated with Fourier series analysis for a real valued and complex valued periodic square wave sampled using appropriate sampling frequency.
11. Verification of Fourier series properties associated with down sampling of a periodic square wave sampled using appropriate sampling frequency.
12. To compute Z transform of a sequence.

ECL204: Measurements and Instrumentation [(3-0-0); Credits: 3]

Course outcomes

1. Impart and respond to need for rigorous and formal metrology concepts in designing measurement Systems.
2. Comprehend the errors is measurements and their rectification.
3. Apply the knowledge to select and identify specific Sensors (or Complete instruments) for processes.
4. Examine the operating principles of a range of widely used instruments.
5. Design of Signal Conditioning circuit and display devices for measurement systems.

CO-PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1									1	3	2	2
CO2	3	2	2									1	2	3	1
CO3	3	2	2									1	1	2	3
CO4	2	1			1							1	2	3	1
CO5	3	2	2	1	2		1					1	2	2	3

Course Content:

Introduction to Measurements: Static characteristics, Dynamic Characteristics.
Errors: Errors and statistical analysis in measurement systems, least square fit of experimental data in measurement systems
DC bridges: Wheatstone Bridge, Kelvin Bridge
AC bridges: Inductance and capacitance measurements
Analog instruments: PMMC galvanometer, DC ammeters , Ohmmeter: Series and shunt type, VOM, watt hour meter, instrument transformers power factor meter, Q- meter.
Temperature Measurements: RTDs and Thermistor characteristics; Thermocouples, Laws and cold junction compensation, Radiation pyrometers, optical pyrometer.
Pressure measurement: pressure gauges- strain gauges, Bourdon tubes, bellows, diaphragms; Electrical methods – Piezoelectric transducers, elastic elements with LVDT.
Flow measurement: Introduction, flow meters classification, differential pressure flow meters, Electromagnetic flow meter, Hot wire anemometer.
Additional Senors: Hall effect sensor, Ultrasonic based sensors .
Design of ADC and DAC : Flash, Single and Dual slope integrating, successive approximation, and sigma-delta, weighted R, R-2R ladder, Characteristics of ADC and DAC.
Analysers: Measurement of period and time and frequency, Q meter
Display Device: Cathode Ray tube (CRT), CRT circuits, Deflection systems, Delay line, Spectrum analyzer, DSO.
Signal Conditioning circuit design: Signal Conditioning Circuits for measurement systems, IEEE488Bus: Principles of operation, protocols.

Text Books:

1. A.D. Helfrick and W.D. Cooper, ”Modern Electronic Instrumentation and Measurement Techniques”, Prentice Hall India Private Ltd., New Delhi, 2010.
2. Earnest . O Doeblin, “Measurement Systems Application and Design”, McGraw Hill International edi-tions, the edition, 1990.
3. John P. Bentley, “Principles of Measurement Systems”, 4th Edition, Pearson Education, 2004

Reference books:

1. A.K.Sawhney, “A Course in Electrical and Electronic Measurements and Instrumentation”, DhanapatRai & Sons, 2000.
2. A.J.Bouwens, “Digital Instrumentation”, McGraw Hill, 1986.
3. Renganathan, S.,” Transducer Engineering”, Allied Publishers, New Delhi, 2003.
4. H. S. Kalsi, “Electronic Instrumentation”, Tata McGraw Hill Publishing Company Ltd.,1995.David A. Bell, ”Electronic Instrumentation and Measurements”, Oxford University Press India; 3rd Edition,2013
5. John G. Webster, ”Sensors and Signal Conditioning”, Wiley Inter Science, 2nd edition.

ECP204 Measurements and Instrumentation [(0-0-2); Credits: 1]

Course Outcomes:

1. Design and validation of DC and AC bridges.
2. Study the dynamic response and the calibration of few instruments
3. Learn about various measurement devices, their characteristics, their operation and their limitations
4. An understanding of statistical data analysis for instruments
5. An understanding of computerized data acquisition for instrument design.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	-	-		-	-	-	-	1	1	2	2
CO2	2	2	2	1	-	-	2	-	1	1	-	1	1	2	3
CO3	2	2	1	1	-	-	3	-		1	1	1	1	2	3
CO4	3	3	3	3	1	-	2	-	2	1	2	1	2	2	1
CO5	2	1	3	1	1	-	-	-	2	1	1	1	1	1	3

List of Experiments:

1. Study the characteristics of LVDT.
2. Study the characteristics of Pressure Cell.
3. Study Characteristics of Thermistor and design signal conditioning circuit.
4. Torque measurement.
5. Strain measurement.
6. Liquid level measurement
7. Linear regression (basic fitting) using MATLAB and Design filtering algorithms for noise measurement
8. Study Characteristics of Thermistor and design signal conditioning circuit.
9. Capacitance measurement using Signal conditioning circuit.
10. Design of R-2R Digital to Analog Conversion.

Mini Project: Liquid Level measurement using ultrasonic sensor

ECL 216: Digital Circuits and Hardware Design [(3-1-0); Credits: 4]

Prerequisite: First Year Course on Electrical Engineering.
Course Outcomes:

The student will be able to,

1. realize logic functions utilizing fundamentals of combinational and sequential circuit designing principles.
2. understand the fundamentals of the digital system design.
3. design complex digital systems
4. identify and remove the faults occur in the digital systems.
5. understand the basics of hardware description languages and realize the circuits using the field programmable gate array logics.

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

Contents:

- Quine Maclausky method till five variables don't care.
- Sequential circuits- Registers, Counters, their design, asynchronous & synchronous designs, Moore & Mealey machines with overlapping and non-overlapping case, Memory elements, Excitation tables, Race free design
- Finite state machines, Controller design using minimal number of flip-flop method and shift register based method, ASM charts, State assignments, minimizations, PLA, FPGAs
- Introduction to HDL, Analysis & Synthesis, CAD tools, Netlists, placements, static timing analysis
- Digital system design- Bus structure, Simple processor, Bit counting circuit, Clock synchronization, timing
- Asynchronous sequential design logic, hazards –types, ROM-SRAM etc, fault models, complexity
- Programming of FPGAs with sample circuit/processor

Books:

1- Switching and Finite Automata Theory South Asian Edition Niraj K Jha and Zvi Kohavi, Cambridge, 3rd Edition
2- Digital Design - With an Introduction to Verilog HDL, Moris Mano and M. D. Ciletti, Pearson, 5th Edition
3- Fundamentals of Digital Logic with VHDL Design, Stephen Brown and Zvonko Vranisic, 3rd Edition, TMH

ECP 216: Digital Circuits and Hardware Design [(0-0-2); Credits: 1]
Course Outcomes:

Student will be able to

1. Realize logic functions utilizing fundamentals of combinational and sequential circuit designing principles.
2. Understand the fundamentals of digital system design.
3. Design complex digital systems
4. Identify and remove the faults occurring in the digital systems.
5. To understand the basics of hardware description languages and realize the circuits using the field programmable gate array logics.

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

Contents:

Perform 10 experiments on Sequential Circuits, HDL programming and FPGA board.

MAL210 Linear Algebra and Partial Differential Equations [3-1-0, Credits: 4]

Course Outcomes:

1. Understand the basic concepts of linear algebra such as vector space, basic vector operations, basis, dimension and Linear transformations etc
2. Relate matrices and linear transformations, compute Eigen values and Eigen vectors of linear transformations and obtain various variants of diagonalisation of linear transformations.
3. Understand the fundamentals of Fourier series expansion and Fourier transform.
4. Explore the properties of Fourier series & Fourier transform and its applications in Science and Engineering.
5. Expose the concepts of the solutions to the PDE over the bounded domain.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	2	-	-	-	-	-	-	-	1	1	-	-
CO2	3	3	1	3	-	-	-	-	-	-	-	1	-	1	-
CO3	3	3	1	3	-	-	-	-	-	-	-	1	-	1	-
CO4	3	3	1	2	-	-	-	-	-	-	-	1	-	1	-
CO5	3	3	2	3	-	-	-	-	-	-	-	2	2	1	-

Syllabus

Vector space, subspaces, linear dependence/independence, basis, dimension, linear transformation, range space and rank, null space and nullity, rank nullity theorem. matrix representation of a linear transformation, linear operators on Rn and their representation as square matrices, invertible linear operators, inverse of a non-singular transformations.

Eigen values and eigenvectors of a linear operator, characteristic equation, bounds on eigen values, diagonalizability of a linear operator, invariant sub spaces, annihilators, minimal polynomials. Inner product spaces, vector and matrix norms; ortho normal sets, Gram-Schmidt orthogonalization process; projections and least squares approximation, Ad-joint operator, normal, unitary and self-adjoint operator., Spectral theorem for normal operator, SVD, QR decomposition, applications of linear algebra in engineering.

Fourier series, half range sine and cosine series expansions, exponential form of Fourier series.

Classification of linear second order partial differential equations, method of separation of variables, Solution of One-dimensional wave equation, heat equation, Laplace equation (Cartesian and polar forms).

Text books/ References:

1. G. Strang, Linear algebra and its applications , Thomson Publications.
2. E. Kreyszig, Advanced engineering mathematics , John Wiley publications.
3. Hoffman and Kunje, Linear Algebra, Prentice Hall of India.
4. S. Kumaresan, Linear algebra - A Geometric approach, Prentice Hall of India.
5. Jain, R.K. and Iyengar, S.R.K.; Advanced Engineering Mathematics; Narosa Publishers, 2005.

ECL304 Digital Signal Processing [(3-0-0); Credits: 3]

***Pre-requisite: ECL211**

Course Outcomes

1. Able to do analysis and characterization of the discrete time systems
2. Use Fourier analysis concept for frequency domain representation and analysis
3. Realize the implementation of discrete time systems
4. Design the different aspects of IIR and FIR filters
5. Calculate the spectral density parameters for measuring the performance.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	-	-	-	-	-	-	-	-	-	-	3	1	-
CO2	1	3	2	-	-	-	-	-	-	-	-	1	3	-	-
CO3	1	2	3	-	-	-	-	-	-	-	-	1	2	3	-
CO4	1	3	3	2	-	-	-	-	-	-	-	1	-	3	2
CO5	1	3	-	1	-	-	-	-	-	-	-	1	2	1	-

Contents:

Introduction to discrete time signals and systems

Discrete Fourier Transform, Linear filtering methods based on the DFT, Filtering of long sequences. Direct computation of the DFT, Divide and Conquer approach, Radix -2, radix-3 and radix-4 Fast Fourier Transform, Goertzel algorithm, Chirp-z transform, quantization effect in computation of the DFT.

Implementation of the Discrete time systems: Structure for the realization of discrete time FIR and IIR systems, Direct Form, cascade form, Frequency sampling structure, lattice structure. State space system analysis and structures. Round-off effects in digital filter

Design of Digital filters: Magnitude and phase response of digital filter, frequency response of Linear phase FIR filters, Design Techniques for FIR (Lowpass, highpass, bandpass and bandreject) filters. Design of Optimal Linear phase FIR Filters, Design of Minimum phase FIR Filters.

IIR filter design by approximation of derivatives, impulse invariant approach and bilinear transformation. Butterworth filters, Chebyshev filters, Inverse Chebychev filter and elliptic filters, Design of Lowpass, highpass, bandpass and band reject IIR filters. Spectral transformation of IIR filter, Effects of Finite word length in digital filters,

Spectral estimation, Energy Density Spectrum, Estimation of autocorrelation and power spectrum, DFT in spectral estimation, Parametric and nonparametric method for power spectrum estimation.

Text/Reference Book:

1. Discrete Time Signal Processing, Oppenheim & Schafer, PHI Ltd, Third Edition
2. Digital Signal Processing: Principles Algorithms and Applications, Proakis John and Manolakis.
3. Digital Signal Processing- A computer based approach, Sanjit K. Mitra, McGraw Hill Education.

ECP304 Digital Signal Processing [(0-0-2); Credits: 1]

Course Outcomes:

1. To verify and implement basic digital signal processing techniques like convolution, correlation and Fourier transform.
2. To design and implement different FIR filters
3. To design and implement different IIR filters
4. To characterize stochastic process
5. To implement basic digital processing algorithms in dedicated DSP platforms

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	-	-	-	-	-	-	-	-	-	-	3	1	-
CO2	1	3	2	-	-	-	-	-	-	-	-	1	3	-	-
CO3	1	2	3	-	-	-	-	-	-	-	-	1	2	3	-
CO4	1	3	3	2	-	-	-	-	-	-	-	1	-	3	2
CO5	1	3	-	1	-	-	-	-	-	-	-	1	2	1	-

Contents:

1. Compute linear convolution, circular convolution and cross correlation of two sequences.
2. Verify different properties of Discrete Fourier Transform.
3. Implement different FFT algorithms.
4. Design and implementation of low pass, high pass, band pass and band reject FIR filters.
5. Design and implementation of low pass, high pass, band pass and band reject IIR filters of different types.
6. Computation of power spectral density, correlation function and correlation matrix of stochastic systems.
7. Implementation of basic digital signal processes algorithms for different applications like demising, edge detection etc. using computer programming.
8. Implementation of basic digital signal processes algorithms for different applications like denoising, edge detection etc. using digital signal processors like TMS DSP kits.

Text/Reference Book:

1. Discrete Time Signal Processing, Oppenheim & Schafer, PHI Ltd, Third Edition
2. Digital Signal Processing: Principles Algorithms and Applications, Proakis John and Manolakis.
3. Digital Signal Processing- A computer based approach, Sanjit K. Mitra, McGraw Hill Education.

ECL305 Electromagnetic Field [(3-1-0); Credits: 4]

Course Outcomes

After completing this course the student will demonstrate the knowledge and ability to:

1. apply vector calculus to understand the behavior of static electric and magnetic fields in standard configurations in different coordinate systems.
2. calculate electric and magnetic field due to charge, charge distributions in space.
3. solve boundary value problems for electromagnetic fields.
4. describe and analyze electromagnetic wave propagation in free-space.
5. to understand the concept of power associated with an EM wave.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	-	-	-	-	-	-	-	-	-	1	2	2
CO2	3	3	1	-	-	-	-	-	-	-	-	-	2	2	3
CO3	3	3	2	1	-	-	-	-	-	-	-	-	2	2	3
CO4	3	3	2	1	-	-	-	-	-	-	-	1	2	2	3
CO5	3	3	1	1	-	1	-	-	-	-	-	1	2	2	1

Contents:

Vector calculus: Cartesian, Cylindrical and spherical co-ordinate systems, differential lengths, surfaces and volumes

Electrostatics: Coulomb's law, Electric field, intensity, electric flux density, Gauss's law and applications, divergence and divergence theorem, potential difference and potential gradient, Electric dipole and dipole moment, Energy in electric field.

Steady magnetic fields: Biot Savart's law, Amperes circuital law and application, Curl and Stroke's theorems, Magnetic flux density and magnetic flux, scalar and vector magnetic potentials, Maxwell's equations and time varying fields, Faraday's law, displacement current, Maxwell's Equations in point & integral form, Retarded potentials.

Uniform Plane waves: Maxwell's equation in phasor form, wave equation in general medium and perfect dielectric mediums, Solution of wave equations, intrinsic impedance, velocity and wavelength, conductors and dielectrics, depth of penetration, Poynting's vector theorem.

Reflection of Electromagnetic Waves: Reflection of Electromagnetic waves: Normal incidence, standing waves, laws of reflection, reflection of obliquely incident waves, Brewsters angle.

Text Books

1. David K. Cheng , “Field and Wave Electromagnetics” 2E, Pearson
2. William H. Hayt, Jr., John A. Buck, “Engineering Electromagnetics”, 6E, Tata McGraw Hill Ed.
3. M.N.O. Sadiku, “Elements of Electromagnetics” 3E, Oxford .

Reference Books

1. John D. Kraus, Keith R. Carver “**Electromagnetics”** McGraw-Hill.
2. Jorden, Ballman, “ Electromagnetic Fields & Radiating Systems”, 3E, PHI.

ECL315 Microprocessors and Microcontrollers [3-0-0; Credits: 3]

*Pre-requisite: Digital Circuits and Hardware Design

Course outcomes:
Students will
1. Recall concepts of microprocessor and microcontroller architecture
2. Learn, practice, and implement programming using concepts of microprocessor and microcontroller.
3. Interface peripherals and programs to solve prototype problems.
4. Design real-life/ engineering, industry, or consumer applications.
5. Distinguish, Manage, and Assemble the concepts of RTOS (Real-Time Operating System)

CO-PO mapping:

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	-	-	-	-	-	-	-	-	2	-	1	-
CO2	2	2	3	1	1	-	-	-	-	-	-	2	1	2	1
CO3	2	2	3	1	2	-	-	-	-	-	1	1	2	3	2
CO4	3	3	3	2	2	-	-	-	-	-	1	1	2	3	3
CO5	1	-	-	-	-	-	-	-	-	-	-	1	1	-	-

Contents:
Introduction to 8086 – Microprocessor architecture – Stacks - Interrupts and interrupts service routines – Byte and String Manipulation. 8086 signals – Basic configurations – System bus timing — System Bus Structure

Introduction to Microcontrollers, Programming Model and Architecture of the 8051, Program Development Process and Tools, Addressing Modes and Instruction Set, The 8051 Hardware, System Design and Troubleshooting, Programming in C, Input/Output Ports, Timers, Serial Communications, Interrupts, Interfacing Keyboards, Display Devices: LED, Seven Segment Display and LCD, ADC, DAC, Relays, Stepper, DC Motors, etc., External Memory and Real-Time Clock, I2C and SPI Protocols, design examples, Concepts of RTOS.

Books:

1. M A Mazidi, J G Mazidi, R D McKinlay, The 8051 Microcontroller and Embedded Systems Using Assemble and C, Pearson/Prentice Hall, 2nd Ed
2. Kenneth Ayala, The 8051 Microcontroller, Cengage learning, India, 2004 3rd Ed
3. Lyla B Das; Embedded Systems and Integrated Approach, Pearson, India, 2013, first edition.
4. KM Bhurchandi, A K Ray, Advanced microprocessors and Peripherals, McGraw Hill Education India, 2012, 3rd ed.
5. Kamal, Raj. Microcontrollers: Architecture, Programming, Interfacing and System Design. India, Pearson Education, 2009.
6. K V Shibu, Introduction to Embedded Systems, Tata McGraw Hill Education, India, 2009

ECP315 Microprocessors and Microcontrollers [0-0-2; Credits: 1]

Course outcomes:

Students will

1. Recall concepts of microprocessor and microcontroller architecture
2. Learn, practice, and implement programming using concepts of microprocessor and microcontroller.
3. Interface peripherals and programs to solve prototype problems.
4. Design real-life/ engineering, industry, or consumer applications.
5. Distinguish, Manage, and Assemble the concepts of RTOS (Real-Time Operating System)

CO-PO mapping:

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	-	-	-	-	-	-	-	-	2	-	1	-
CO2	2	2	3	1	1	-	-	-	-	-	-	2	1	2	1
CO3	2	2	3	1	2	-	-	-	-	-	1	1	2	3	2
CO4	3	3	3	2	2	-	-	-	-	-	1	1	2	3	3
CO5	1	-	-	-	-	-	-	-	-	-	-	1	1	-	-

Contents:

10 experiments based on the theory content in ASM and C language.

ECL301 Analog Communication [(3-1-0); Credits: 4]

***Pre-requisite: ECL211**

Course outcomes

Students will

1. understand issues related to transmission of signals through communication channels
2. understand analog communication systems using amplitude modulation and demodulation.
3. understand analog communication systems using angle modulation and demodulation.
4. Be familiar with analog radio transmitters and receivers.
5. be familiar with analog pulse communication systems.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	-	-	-	-	-	-	-	1	3	2	1
CO2	3	3	1	1	-	1	-	-	-	-	-	1	3	1	1
CO3	3	2	1	-	-	-	-	-	-	-	-	-	2	2	2
CO4	2	2	2	1	-	-	-	-	-	-	-	-	1	1	2
CO5	2	2	2	-	-	1	-	-	-	-	-	1	1	1	1

Contents:

Signal Analysis: Fourier series representation of periodic signals, Fourier transform, Properties of Fourier transform, Convolution, Analysis of Linear time invariant system.

Transmission of signals through systems: Criteria for distortion less transmission, ideal filters, distortions in practical systems, power and energy of signals.

Amplitude modulation: Need of modulation, AM DSB-SC, SSB-SC and vestigial side band modulation and demodulation, AM transmitter (broadcast and low power), FDM.

Angle modulation: FM and PM, reactance FET modulator Armstrong method, Foster-Seely discriminator, PLL detector, Stereophonic FM, Spectrum of FM, Narrow band and wide band FM, FM transmitter (broadcast and low power).

Radio receivers: TRF and super-heterodyne receiver, AGC, FM receiver, sensitivity, selectivity, image frequency rejection measurements, block schematic of communication receiver and its special features. Transceivers for wireless mobile communication devices.

Analog pulse modulation: Sampling theorem, PAM, PWM, PPM, generation & detection of these pulse modulated signals, TDM, Noise in communication systems.

Books

1. Haykin Simon; Introduction to Analog & Digital Communication Systems; John Wiley
2. Lathi B.P.; Modern Analog & Digital Communication Systems; John Wiley
3. Kennedy; Electronic Communication Systems; TMH
4. Frenzel Louis; Communication Electronics (3e); TMH
5. Gandhi Abhay; Analog and Digital Communication, Theory and Lab Work, Cengage Learning
6. Schoenbeck, “Electronic Communication Modulation and Transmission”, PHI

ECP301 Analog Communications [(0-0-2); Credits: 1]

Course Outcomes:

Students will

1. Be able to use laboratory instruments such as analog & digital oscilloscopes and spectrum analyzer.
2. Verify the spectra of commonly used test signals and transfer functions (magnitude) of various analog filters.
3. Be able to characterize modulated signals such as AM, FM, PAM, PPM and PWM.
4. Gain working knowledge of various modulators and demodulators.
5. Gain working knowledge of radio transmission and reception

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	2	2	-	-	-	-	1	3	2	2
CO2	2	2	2	2	2	2	2	1	-	-	-	1	3	2	2
CO3	2	2	2	2	2	2	2	-	-	-	-	-	3	2	3
CO4	2	2	2	2	2	2	2	2	-	-	-	-	2	2	3
CO5	1	1	1	1	2	2	2	2	2	2	-	1	2	2	1

List of Assignments in Analog Communication

Assignments No. 1

Testing of Analog oscilloscope & function generator

Objectives

- Probe checking using ‘calib’ o/p of scope.
- Difference between ALT and CHOP mode.
- Observing various triggering modes.
- Observing waveforms of function generator.

Assignments No. 2

Testing of digital oscilloscope & function generator

- Probe checking and calibration/adjustment/compensation.
- Study of trigger menu/auto setting
- Observing waveforms of function generator O/P.

Assignments No. 3

Testing of Spectrum analyzer

- Observing 48 MHz test signal.
- Testing of cable using tracking generator.
- Harmonics of sine, square & triangular waves.

Assignments No. 4

To perform different parameter measurement using Spectrum Analyzer HM-5014.

- To measure frequency and level of a given unknown signal.
- To measure frequency of TV transmission signal.

- To measure harmonics of sine wave.
- To measure harmonics of square wave.
- To measure harmonics of triangular wave.

Assignments No. 5

To analyze responses of various filters for estimation of cut off frequencies using Spectrum Analyzer.

- To check frequency response of a 'LOW PASS' Filter.
- To check frequency response of a 'HIGH PASS' Filter.
- To check frequency response of a 'BAND REJECT' Filter.
- To check frequency response of a 'BAND PASS' Filter.
- To check frequency response of a 'High Frequency DC coupled Amplifier'.

Assignments No. 6

To perform channel parameter measurement for an A-V signal using Spectrum Analyzer.

- To observe channel Modulator output on Spectrum Analyzer.
- To observe Mixer output on Spectrum Analyzer.

Assignments No. 7

DSB/SSB Transmitter-Receiver Trainer ST 2201 & 2202

To formulate full AM generation and study technique of AGC also to study working of AM detector and DSB-SC generator of estimate modulation index for different settings.

- Double Sideband AM Generation.
- To calculate modulation index of DSB wave by trapezoidal pattern.
- Double Sideband AM Reception.
- Study of Diode Detector.

Assignments No. 8

DSB/SSB Transmitter-Receiver Trainer ST 2201 & 2202

To estimate performance improvement because of SSB AM generation and to study it's demodulation.

- Single Sideband AM generation.
- Single Sideband AM reception.
- Operation of the Automatic Gain Control (AGC) circuit.

Assignments No. 9

Frequency Modulation and Demodulation Trainer ST2203

To study different FM generation techniques under direct category.

- To study frequency modulation using Varactor modulator.
- To study frequency modulation using Reactance modulator.

Assignments No. 10

Frequency Modulation and Demodulation Trainer ST2203

To analyze and compare working of different FM detectors.

- To study operation of Detuned resonant circuit.
- To study operation of Quadrature detector.
- To study operation of Phase-Locked Loop detector.
- To study operation of Foster –Seeleye detector.
- To study operation of Radio detector.

Assignments No. 11

DSB/SSB Transmitter-Receiver Trainer ST 2202

To estimate three basic parameters of an AM receiver by studying it's working.

- To plot selectivity curve for radio receiver.
- To plot sensitivity curve for radio receiver.
- To plot fidelity curve for radio receiver.

Assignments No. 12

PAM, PPM, PWM, Modulation Trainer ST 2110

To verify sampling theorem and study PAM with different styles of sampling.

- To study Pulse Amplitude Modulation (PAM) using Natural and Flat top sampling.
- To study PAM using sample and hold sampling.
- To study PAM and Demodulation with sample, sample and hold and flat top.

Assignments No. 13

PAM, PPM, PWM, Modulation Trainer ST 2210

To study PPM (time modulation) and demodulation for various signals.

- To study PPM using DC input.
- To study PPM using Sine wave input.
- To study PPM Demodulation.

Assignments No.14

PAM, PPM, PWM, Modulation Trainer ST 2210

To analyze (time modulation) PWM and demodulation.

- To study PWM using different sampling frequency.
- To study Pulse Width Demodulation.

Assignments No. 15

PAM, PPM, PWM, Modulation Trainer ST 2210

To formulate voice transmission using all types of Pulse modulation technique.

- To study Voice Link using Pulse Amplitude Modulation.
- To study Voice Link using Pulse Position Modulation.
- To study Voice Link using Pulse Width Modulation.

ECP307 Electronics Product Engineering Workshop [(0-0-2); Credits: 1]

Course outcomes:

1. Identify the tools used for electrical wiring, electrical accessories, wires, cables, batteries and standard symbols
2. Develop the connection diagram, identify the suitable accessories and materials necessary for wiring simple lighting circuits for domestic buildings
3. Identify and test various electronic components
4. Draw circuit schematics with EDA tools. Assemble and test electronic circuits on boards
5. Work in a team with good interpersonal skills

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	-	-	-	-	-	-	-	1	-	-	2	-	-
CO2	2	-	-	1	-	1	-	1	2	2	-	2	2	-	-
CO3	3	-	-	-	-	-	-	-	-	-	-	2	3	-	-
CO4	3	-	-	-	2	-	-	-	-	-	-	2	3	-	-
CO5	-	-	-	-	-	-	-	-	3	2	-	2	-	-	-

Contents:

Disassembling and assembling electronic products. Familiarization/Identification of electronic components with specification (Functionality, type, size, color coding, package, symbol, cost etc. [Active, Passive, Electrical, Electronic, Electromechanical, Wires, Cables, Connectors, Fuses, Switches, Relays, Crystals, Displays, Fasteners, Heat sink etc.)

Drawing of electronic circuit diagrams using BIS/IEEE symbols and introduction to EDA tools, Interpreting data sheets of discrete components and ICs, Estimation and costing.

Familiarization/Application of testing instruments and commonly used tools. [Multimeter, Function generator, Power supply, DSO, etc.] [Soldering iron, Desoldering pump, Pliers, Cutters, Wire strippers, Screw drivers, Tweezers, Crimping tool, hot air soldering and desoldering station etc.] Testing of electronic components [Resistor, Capacitor, Diode, Transistor and FETs, etc.]

Inter-connection methods and soldering practice. [Bread board, Wrapping, Crimping, Soldering—types—selection of materials and safety precautions, soldering practice in connectors and general purpose PCB, Crimping.] Printed circuit boards (PCB) [Types, Single sided, double-sided, PTH, Processing methods, Design and fabrication of a single-sided PCB for a simple circuit with manual etching (Ferric chloride) and drilling.] Assembling of electronic circuit/system on general purpose PCB, test and show the functioning of any real-life circuits.

ECL308 Analog Circuit Design [(3-0-0); Credits: 3]

***Pre-requisite: Electronic Circuits**

Course Outcomes

1. This course provides in depth knowledge about operational amplifiers using BJT and FET.
2. Through the course student will learn about various op-amp based ICs for various applications.
3. Through the course student is able to design op-amp based circuits required in embedded system design, communications, instrumentation etc.
4. It facilitates students to learn circuit design concept.
5. It helps students to know about analog filter design.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	-	-	-	-	-	-	-	-	-	2	-	2	1
CO2	3	1	-	-	-	-	-	-	-	-	-	1	1	2	1
CO3	3	3	3	-	-	-	-	-	-	-	-	1	3	3	2
CO4	3	3	3	-	-	-	-	-	-	-	-	1	1	2	2
CO5	3	3	3	-	-	-	-	-	-	-	-	1	1	1	1

Contents

- OPAMP configuartions: inverting, non-inverting, differential amplifier configurations, negative feedback, voltage gain, input & output impedance, Bandwidth.
- Parameters of op-amp: Input offset voltage, input bias and offset current, Thermal drift, CMRR, PSRR, Frequency response, study of 741 IC parameters and internal circuit of 741
- Linear applications: DC, ac amplifiers, summing amplifier, differential amplifier, instrumentation amplifier, V to I and I to V converters (floating load and grounded load), Integrator, Differentiator. Design of constant current sources
- Non- linear applications: Comparators, Schmitt Trigger, Clipping and Clamping circuits, Absolute value circuits, Peak detectors, Sample and hold circuits, Log and antilog amplifiers, Half wave, full wave rectifier, Design of function generators (square, triangle)
- Introduction to active filters: First / Second order, low/ high/ bandpass, band reject active filters, All pass filter, Design of filters upto sixth order (equal component method and unity gain method)
- Oscillators: Design of RC and LC oscillators using op-amp , design of Square wave and triangular waveform generators.
- ADC and DAC: A to D converters, (all types), design examples, D to A converters(all types), design examples of DAC, performance parameters for DAC and ADC
- Study of ICs: LM-555 timer IC and it's applications, LM-565 Phase locked loop working principle and applications, LM-723 voltage regulator (variants such as low voltage, high voltage, low current and high current) .

Text Books

1 Tobey, Graeme ,Huelsman , "Operational amplifiers, Design and applications", McGraw Hills, Edition

2. Gaikwad R.A, "Operational Amplifiers and Linear Integrated Circuits" , PHI 1990 Edition

Reference Books

1. Fransis S , "Design with OPAMPS and Analog Ics", McGraw Hills.
2. Fiore J.M , "OPAMPS and Linear Ics" , delmer-Thomson",USA 2001.
3. Sedra, Smith, "Microelectronic circuits", Oxford, 7th edition.
4. D. Roy Chaudhary, "Linear integrated circuits", New AGE publishers.

ECP308 Analog Circuit Design [(0-0-2); Credits: 1]

Course Outcomes:

Students should

1. Have good knowledge about operational amplifiers.
2. Learn about various ICs such as 741 and 555.
3. be able to design op-amp based circuits required in embedded system design, communications, instrumentation etc
4. be able to simulate circuits using multisim tool.
5. know about analog filter design.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	2	-	-	-	3	2	1	1	-	2	1
CO2	3	-	-	-	1	-	-	-	2	2	1	1	1	2	1
CO3	1	-	2	-	1	-	-	-	2	2	1	1	2	3	2
CO4	2	1	2	-	1	1	-	-	2	1	2	1	-	1	1
CO5	2	1	2	-	2	-	1	-	2	2	1	1	1	1	1

List of experiments:

• Design Experiments

1. op-amp characteristics (02-03 experiments)
2. linear applications of op-amp (3-4 experiments)
3. non-linear applications of op-amp (3-4 experiments)
4. filter design (2-3 experiments)
5. based on IC555 (2-3 experiments)

• Simulation Based Experiments

1. linear applications of op-amp using multisim or T-spice
2. non-linear applications of op-amp using multisim or T-spice
3. IC555 using multisim or T-spice

ECL312 Control Engineering [(3-0-0); Credits: 3]

***Pre-requisite: ECL211**

Course Outcomes

1. Study about the modelling of the linear dynamic systems.
2. Understand the concept of stability of system.
3. Analyse the systems in time and frequency domain.
4. Gain the knowledge of state space modelling of system and its analysis.
5. Use the concept of feedback to improve the system performance

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	-	-	-	-	-	-	-	-	1	3	-	-
CO2	3	1	-	-	1	-	-	-	-	-	-	2	3	-	-
CO3	2	3	-	-	2	-	-	-	-	-	-	-	1	2	-
CO4	3	2	-	-	1	-	-	-	-	-	-	1	3	-	-
CO5	1	3	3	-	-	-	-	-	-	-	-	1	1	2	3

Contents:

Review of control system components, Open loop and closed loop systems, mathematical modeling and representation of physical systems, transfer functions for different type of systems, block diagram reduction, Signal flow graphs and Mason's gain formula reduction.

Time response characteristics, transient response of first order, second order and higher order systems, Steady state errors, Performance analysis for P, PI and PID controllers

Introduction to stability, Routh Hurwitz stability criterion, Root locus plots, stability margins

Frequency response analysis: Nyquist stability criterion, Bode plots and stability margins in frequency domain. Basics of control design, the proportional, derivative and integral actions. Design using Root locus ad bode plots, effect of zeros, minimum and non-minimum phase systems.

Compensation Techniques: Introduction of compensation techniques, lag, lead and lag-lead networks, design of compensation network using time response and frequency response of the system Feedback compensation using P, PI, PID controllers

State model of linear time invariant (LTI) systems, transfer function from ordinary differential equations, canonical variable diagonalization, system analysis by transfer function and state space methods for continuous and discrete time systems convolution integral; State transition matrices and solution of state equations for continuous and discrete time systems.

Concept of controllability and observability, definitions, state and output controllability and observability tests for discrete systems. Effect of state feedback on controllability and observability, design via state feedback full order observer, reduced order observers design of state observers and controllers.

Text Books:

1. Nagrath I. J. and Gopal M., "Control System Engineering", 5th Ed, 2008
2. Private Ltd. Kuo B. C., "Automatic Control Systems", 8th Ed., Wiley India. 2008.
3. Ogata K., "Modern Control Engineering", 4th Ed., Pearson Education. 2008.
4. Dorf R. C. and Bishop R. H., "Modern Control Systems" Pearson Education. 2008.
5. Norman S. N., "Control Systems Engineering", 4th Ed., Wiley India. 2008.

ECP312 Control Engineering [(0-0-2); Credits: 1]

Course Outcomes:

Student will

1. Be familiar with various components used in building control systems.
2. Analyze any transient response and frequency response of different order systems.
3. Check for stability.
4. Learn simulation of control system using software tools.
5. Study the lead and lag networks using discrete components.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	2	3	-	-
CO2	-	2	2	-	-	-	-	2	3	3	-	-	-	3	1
CO3	-	2	3	1	-	-	-	2	3	3	-	-	2	2	-
CO4	-	2	2	-	3	-	-	2	3	3	-	2	3	-	-
CO5	2	2	-	1	1	-	-	2	3	3	-	2	3	1	-

List of Experiments:

1. Control system simulation using MATLAB and Simulink
   (a) To study the command on control system toolbox in MATLAB and solve nonlinear differential equation using the ODE command in MATLAB
2. To study the characteristics of Potentiometer as an error detector.
3. To Study transient response of second order R-L-C Circuit using discrete components.
4. To study the effect of addition of pole to the second order closed loop control discrete components.
5. Experimental determination of transfer function of lead and lag network
   To draw the Bode plot and obtain the transfer function of lead and lag networks and compare the results with theoretical plots.
6. To Study the effect of PID controller using a Kit.
7. To study the level control system and tune the PID parameters.

ECL303 Digital Communication [(3-0-0); Credits: 3]

***Pre-requisite: ECL301**

Course outcomes

Students will

1. be able to describe concepts of information theory and their applications to efficient coding of speech, audio, image and video signals.
2. be able to describe applications of information theory in efficient coding of data sources.
3. be able to critically think and solve problems related to digital transmission and reception in baseband format.
4. be able to critically think and solve problems related to digital transmission and reception in modulated format
5. be able to describe applications of information theory to error control coding.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	-	1	-	-	-	-	-	1	3	3	3
CO2	3	3	1	1	-	1	-	-	-	-	-	1	3	3	3
CO3	3	3	2	2	-	-	-	-	-	-	-	1	2	3	3
CO4	3	3	2	2	-	-	-	-	-	-	-	1	3	2	2
CO5	3	3	1	1	-	1	-	-	-	-	-	1	2	2	3

Contents:

Introduction to digital communication. Comparison of analog and digital communication. Advantages and disadvantages of digital communication.

Source Coding of Analog Sources: PCM-TDM, Practical PCM-30 system, Delta modulation, Adaptive DM, DPCM, ADPCM.

Source coding of digital sources: Information, entropy, Shannon's source coding theorem, Huffman algorithm, prefix codes.

Generalized digital communication system, geometric interpretation of signals, performance of matched filter receiver and correlator receive in the presence of white noise. Threshold setting and error probability.

Base band transmission: Line coding fundamentals, transmission formats, spectral requirements.

Media used for digital communication; storage and transmission, guided and unguided. types of noise and other impairments. Inter-symbol interference, Nyquist's results for ISI, Eye pattern and adaptive equalization.

Pass-band transmission methods: Binary ASK, PSK and FSK, Quadrature multiplexing, QPSK and QAM methods. Geometric interpretation of signals, performance of matched filter receiver and correlator receive in the presence of white noise.

Spread spectrum methods: Properties of PN sequences, DSSS system, slow and fast FHSS. Block diagrams and performance analysis, carrier and symbol synchronization.

Case studies of transmission methods in telecommunications and computer networking. For example XDSL, 802.3 LANs, WiFi LANs, GSM, CDMA and OFDM based mobile wireless networks.

Error control coding: Shannon's channel capacity theorem, significance of the theorem. Linear block codes generation and decoding, Hamming distance considerations, Cyclic codes and their applications, Convolutional codes and Viterbi decoding algorithm.

Data link layer protocols; ARQ and sliding window protocols; flow control methods; elementary analysis of protocol correctness and performance; Case studies of HDLC and PPP.

Books:

1. Abhay Gandhi, “Analog and Digital Communication, Theory and Lab Work”, Cengage Learning
2. Haykin Simon; “Introduction to Analog & Digital Communication Systems”;John Wiley
3. Lathi B.P, “Modern Analog & Digital Communication Systems”, John Wiley
4. Haykin Simon, “Digital communication” ,Wiley Edition
5. Haykin, Simon, “Communication systems “,Wiley, (4e)
6. Proakis John, “Digital communication”, Tata- McGraw-Hill,(3e)

ECP303 Digital Communication [(0-0-2); Credits: 1]

Course Outcomes:

Students will

1. Be able to analyse simple systems for digital representation of analog signals.
2. Be able to characterize digital transmission in baseband and modulated format
3. Understand receiver design issues in baseband and modulated format.
4. Understand error control coding applied in digital communication
5. Be able to simulate working of digital communication systems through software tools such as Matlab or Scilab.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	2	3	1	-	-	2	2	-	1	3	3	3
CO2	2	2	2	2	3	1	-	-	2	2	-	1	3	3	3
CO3	1	2	2	2	3	1	-	-	2	2	-	1	2	3	3
CO4	1	1	1	1	3	1	-	-	2	2	-	1	2	2	2
CO5	1	2	2	2	3	1	-	-	2	2	-	1	2	3	3

List of Experiments:

1. To perform following experiment on Kit No. ST 2101
a) To observe signal sampling and reconstruction techniques, also verify Nyquist Criteria and aliasing.
b) Analyze the effect of SAMPLE/HOLD circuitry on reconstructed waveform. Also verify effect of sampling pulse duty cycle on the reconstructed waveform in sample and sample hold output.
2. To perform following experiment on Kit No. ST 2101 (Experiment No. 3 of St 2101)
a) To compare the frequency response of 2nd order and 4th order Butterworth Low Pass Filter
3. To perform following experiment 1,2,3 on Kit No. ST 2103 & ST 2104
a) To observe Working of Error Check Code.
b) To Study Analog to Digital conversion.
c) To observe control signal and their timing.
4. To perform following experiment 4,5,6 on Kit No. ST 2103 & ST 2104
a) To perform Time Division Multiplexing.
b) To verify the use of Pseudo Random Sync. Code Generator.
c) To verify the three mode of transmission.
5. To perform following experiment 5,6,7 on Kit No. ST 2103 & ST 2104
a) To verify and use Computer communication using RS 232 interface via ST 2103 & ST 2104.
b) To verify working of multipoint to multipoint Communication using RS 232 interface via 2103 & ST 2104.
c) To verify working of point to multipoint Communication using RS 232 interface via 2103 & ST 2104.
6. To perform following experiment 1,2,3 on Kit No. ST 2105
a) To perform delta modulation and demodulation.
b) To perform and study Adaptive Delta Modulation and Demodulation.
c) To perform Delta Sigma Modulation and Demodulation.
7. To perform following experiment 1 To 7 on Kit No. ST 2106 & ST 2107
a) To Study NRZ (L) Code
b) To verify NRZ (M) Code and it's detection
c) To Observe RZ code and it's detection.
d) To observe Biphase (Manchester) Code and it's detection.

e) To observe Biphase (Mark) Code and it's detection.
f) To study RB Code and it's detection.
g) To study AMI Code and it's detection.
8. To perform following experiment 8 & 9 on Kit No. ST 2106 & ST 2107
a) To study ASK modulation and demodulation.
b) To study FSK modulation and demodulation.
9. To perform following experiment 8 & 9 on Kit No. ST 2106 & ST 2107
a) To study PSK & DPSK.
b) To Study QPSK modulation and demodulation.
10. To Observe the Eye diagram (Expt. No. 12 of ST 2106 & ST 2107)
Four experiments on MATLAB simulator & OCTAVE.

ECL404 RF and Microwave Engineering [(3-0-0); Credits: 3]

***Pre-requisite: ECL305**

Course Outcomes

Students will have

1. Familiarity with basic concepts and theory of RF & Microwave Engineering.
2. Ability to demonstrate waveguide components, assemble them.
3. Ability to solve problems on microwave communication system.
4. Ability to design, implement, analyze and maintain a high frequency communication system
5. Ability to get idea about different microwave network circuit.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	-	-	-	-	-	-	-	1	3	2	1
CO2	3	3	2	2	-	-	-	-	-	-	-	1	3	2	1
CO3	3	2	1	1	-	-	-	-	-	-	-	2	2	2	2
CO4	2	1	2	1	-	-	-	-	-	-	-	2	2	1	1
CO5	2	1	2	1	-	-	-	-	-	-	-	2	1	1	2

Contents:

Introduction: RF & Microwave spectrum, Historical Background, Typical application of RF & Microwaves,

Microwave Tubes: Limitation of conventional tubes in microwaves, Two cavity and multicavity Klystron, Reflex Klystron, Magnetron, Travelling wave tube, Backward wave oscillator – working principles, characteristics.

Semiconductor Microwave Device: Tunnel diode, Gunn diode, IMPATT diode, TRAPATT diode, Microwave bipolar transistor, hetero-junction bipolar transistor, parametric amplifier

Passive Components: S- matrix, Directional coupler, Bethe-hole coupler, Magic tee, Hybrid ring, Circulator, Isolator.

Microwave Measurement: Measurement of VSWR-Low, Medium and High, Measurement of power, Bolometer, Frequency measurement, Impedance measurement. Application of Microwaves: Introduction to satellite communication, Radar, Industrial application of microwaves.

Books

1. Microwave Devices & Circuits S.Y.Liao Pearson Education/PHI
2. Microwave Engineering ,Monojit Mitra ,Dhanpath Rai New Delhi
3. Microwaves ,K.C.Gupta ,New Age Publishers
4. Microwave Engineering , Kulkarni , Dhanpat Rai New Delhi

ECP404 RF and Microwave Engineering [(0-0-2); Credits: 1]

Course outcomes:

1. Be able to analyze different microwave circuits and network.
2. Be able to design different microwave Circuits.
3. Will able to measure different parameters to characterize microwave network.
4. Will be able to evaluate the performance of a microwave circuit.
5. Be able to design a microwave communication link.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	2	2	1	-	-	2	2	-	1	3	2	2
CO2	2	2	2	2	2	1	-	-	1	2	-	1	3	2	2
CO3	2	2	2	2	2	1	-	-	1	2	-	1	2	2	1
CO4	2	2	3	2	2	-	-	-	1	2	-	1	2	1	1
CO5	2	-	3	2	-	-	-	-	-	2	-	1	2	1	1

List of Experiments:

Phase I: Basic experiments

1. V-I characteristics of Gunn diode
2. Study of different characteristics of klystron amplifier
3. Study of different characteristics of reflex klystron amplifier

Phase II: Measurements

1. Frequency measurements
2. VSWR measurements
3. Attenuation measurement
4. Impedance measurement

Phase III: Advance experiments

1. Determination of S matrix
2. Magic Tee E plane Tee H plane Tee

Phase IV: Mini project

ECL 317: Integrated Circuit Design [(3-0-0); Credits: 0]

***Pre-requisite:-** Electronic Circuits

Course Outcomes

Students are able to

1. Acquire knowledge about various CMOS fabrication processes and
2. Infer about the effects of MOS transistor characteristics and fundamental CMOS analog circuits.
3. Analyze and implement various CMOS logic circuits.
4. Learn the design techniques of low voltage and low power CMOS circuits for various applications.
5. Learn and design different types of memory circuits and various structures for low power applications

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	1	-	-	-	-	-	-	-	1	3	1	1
CO2	3	-	2	2	-	-	-	-	-	-	-	1	3	-	2
CO3	3	2	3	3	-	-	-	-	-	-	-	1	3	2	3
CO4	3	2	3	3	-	-	-	-	-	-	-	1	3	2	3
CO5	3	1	1	2	-	-	-	-	-	-	-	1	3	1	1

Course Content:

Flow of circuit design, Fabrication Process Flow: Basic Steps, Layout Design Rules,
CMOS Analog Circuits: MOS Analog models, Current Sources and sinks, References, amplifiers, Differential Amplifiers, feedback topologies, Operational Amplifiers, frequency response, non-linearity, noise, mismatch and stability.
CMOS Digital Circuits: Inverters, Static logic gates, Transmission gates and Flip-Flops, Dynamic logic Gate, clocks, Memory Circuits, phase locked loops (PLL), random circuits.
Circuit characterization and performance estimation: Resistance, capacitance estimation, Switching characteristics, interconnects, delay models, Packaging, I/O pads.
Datapath operations: Addition, Multiplication, Counters, Shifters, Memory elements, FSM Examples.
CMOS Scaling: Short Channel Effects (SCEs), Power dissipation, variability, reliability. Introduction to novel FETs like FinFETS, NCFETs.

Books:

1. “Fundamentals of Microelectronics”, Behzad Razavi, 2nd Edition, McGraw-Hill.
2. “Design of Analog CMOS Integrated Circuits” Behzad Razavi, 1st Edition, McGraw-Hill.
3. “CMOS Circuit design, Layout and Simulation”, R. J. Baker, H W Li, D. E. Boyce, PHI EEE.
4. “Principles of CMOS VLSI Design”, Neil H. E. Weste, Kamran Eshraghian, Addison Wesley.

ECP 317: Integrated Circuit Design [(0-0-2); Credits: 1]

Students are able to

1. Acquire hands on knowledge about various CMOS fabrication processes.
2. Simulate the effects of MOS transistor characteristics and fundamental CMOS analog circuits.
3. Implement and analyze various CMOS logic circuits.
4. Learn the design techniques of low voltage and low power CMOS circuits for various applications.
5. Learn and design different types of memory circuits and various structures for low power applications.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	1	-	-	-	-	-	-	-	1	3	1	1
CO2	3	-	2	2	-	-	-	-	-	-	-	1	3	-	2
CO3	3	2	3	3	-	-	-	-	-	-	-	1	3	2	3
CO4	3	2	3	3	-	-	-	-	-	-	-	1	3	2	3
CO5	3	1	1	2	-	-	-	-	-	-	-	1	3	1	1

Course Content:

1. Design and simulate a circuit using Transistor as a switch.
2. Implementation of the Compound Gate using a combination of series and parallel switch CMOS structures.
3. Implement and simulate the CMOS based XOR gate using Pass Transistor and Transmission Gates.
4. Design, simulate and characterize the Tristate using CMOS.
5. Design and simulate a 8×1 Multiplexer with (a) Complimentary gates design; (b) Transmission Gate; (c) Tristate and (d) 2×1 Multiplexer.
6. Design and simulate the CMOS single stage Common source amplifier.
7. Design and compare the single stage common gate stage and source follower using CMOS for transconductance and resistance of the circuit.
8. Implement and simulate the CMOS based Cascade Amplifier.
9. Implement and simulate the CMOS based Cascode Amplifier and compare it with Cascade Amplifier gain.
10. Simulate and analyze the CMOS based Differential Amplifier with source coupled pair.

ECL405 Waveguides and Antennas [(3-0-0); Credits: 3]

***Pre-requisite: ECL305**

Course Outcomes

1. Be able to understand and analyse guided wave propagation.
2. Be able to analyze and design transmission line based systems and components.
3. Be familiar with radiation theory, antenna theory and terminology.
4. Be able to achieve proficiency of antenna array analysis and design.
5. Be conversant with various types of antennas and related technologies for different applications.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	-	-	-	-	-	-	-	2	2	3	3
CO2	3	3	1	1	-	-	-	-	-	-	-	2	2	3	3
CO3	3	3	1	1	2	-	-	-	-	-	-	1	2	2	2
CO4	3	3	1	1	2	-	-	-	-	-	-	1	2	3	3
CO5	3	3	3	1	3	1	-	-	-	-	-	1	3	3	3

Contents:

Revision of Maxwell's equations for time varying fields and physical significance of Curl, Divergence and Gradient. Waves between parallel planes, TE, TM, & TEM and their characteristics. Attenuation in parallel plane guides wave impedances. TE, TM waves and impossibility of TEM mode in Rectangular waveguide. Different characteristics like group velocity, phase velocity, guide wavelength and wave impedances.

Transmission line equations and their solutions. Transmission line parameters, Characteristic impedances, Propagation constant, Attenuation constant, Phase constant, Waveform distortion, Distortion less transmission lines, loading of transmission lines, Reflection coefficient and VSWR. Equivalent circuits of transmission lines, Transmission lines at radio frequency. Open circuited and short circuited lines, Smith Chart, Stub matching.

Scalar and vector potentials related potentials, field due to a current element, power radiated and radiation resistance for field due to a dipole, power radiated and radiated resistance. Reciprocity theorem applied to antennas. Antenna terminology: Gain, Aperture, Radiation intensity, Directivity, Directive gain, Beam width, Radiation patterns, FBR, Antenna bandwidth etc.

Concept of antenna arrays, Two element arrays and their directional characteristics, Linear array analysis, Broadside and end fire arrays, Principles of pattern multiplication & their application. Polynomial representation, Binomial arrays, Design of broadcast array for a specific pattern, Chebyshev array synthesis.

Analysis of power patterns of various antennas like Parabolic reflectors, Lens antenna, folded dipole, Turnstile antenna, Yagi antenna, Log-periodic antenna, Horn antenna & feeding, Traveling wave antenna, Printed antennas, Case grain antenna, Patch & Micro strip antennas, Superconducting antenna, Rhombic, Helical, Open ended waveguide radiator, Small design problems & applications.

Signal processing antennas or smart antenna, DOA, Principle beam formation & Digital beam formatting, Switched beam systems, Adaptive antennas, introduction to concepts of various signal processing algorithms, Principle of special filtering, Antenna diversity, TRB, SRB and Nulling of interference. Introduction to antenna measurement methods: measurement of Gain, Radiation pattern, Time domain gating, Antenna noise temperature & G/T, Impedance & Bandwidth. Introduction to measurement of cellular radio handset antenna.

Text Books

1. "Antennas and Wave Propagation", K.D.Prasad, Khanna or Satya Publications

2. “Electromagneting waves and radiating systems”, Jhordan & Balmin, Pearson

Reference Books

1. “Electromagnetic field theory and transmission lines”, Raju, Pearson
2. “Antennas and wave propagation”, Raju, Pearson
3. “Antennas for all applications”, Kraus,TMH
4. “Elements of electromagnetism”, Sadiku, Oxford
5. “Electromagnetic Waves”, Shevgaonkar,TMH

—----------

ECD403 Project Course (ECD type) [0-0-4; Credit: 0]

ECD401 Project Phase - I [(0-0-4); Credits: 2]

Course Outcomes

Students will

1. get an opportunity to apply knowledge of several courses in developing a new algorithm or circuit or a larger system.
2. learn working as a team.
3. implement innovative ideas and publish them as a research paper or file a patent.
4. acquire additional skills otherwise not covered in the curriculum
5. gain practical knowledge about the topic including social, commercial, manufacturing, testing, measurements, simulation, marketing and legal issues (as applicable).

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	3	3	1	-	3	-	1	1	2	2	2
CO2	-	1	1	-	1	-	-	1	-	3	3	-	-	-	-
CO3	-	-	-	-	3	1	-	1	-	-	1	3	-	-	2
CO4	-	-	-	-	1	-	-	2	2	-	-	2	-	-	1
CO5	-	-	1	2	2	-	1	-	-	2	1	1	-	2	2

ECD402 Project Phase – II [(0-0-8); Credits: 4]

Course Outcomes

Students will

1. get an opportunity to apply knowledge of several courses in developing a new algorithm or circuit or a larger system.
2. learn working as a team.
3. implement innovative ideas and publish them as a research paper or file a patent.
4. acquire additional skills otherwise not covered in the curriculum
5. gain practical knowledge about the topic including social, commercial, manufacturing, testing, measurements, simulation, marketing and legal issues (as applicable).

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	3	3	1	-	3	-	1	1	2	2	2
CO2	-	1	1	-	1	-	-	1	-	3	3	-	-	-	-
CO3	-	-	-	-	3	1	-	1	-	-	1	3	-	-	2
CO4	-	-	-	-	1	-	-	2	2	-	-	2	-	-	1
CO5	-	-	1	2	2	-	1	-	-	2	1	1	-	2	2

CSL311 Computer Architecture and Organization [(3-0-0); Credits: 3]

***Pre-requisite: Digital Circuits and Hardware Design**

Course Outcomes

Students will

1. help to learn how computers work
2. know in depth principles of computer's working
3. be able to analyze the performance of computers
4. know how computers are designed and built
5. have understanding of issues affecting modern processors (caches, pipelines etc.).

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	2	3	1	-
CO2	3	2	-	-	-	-	-	-	-	-	-	1	3	1	-
CO3	3	2	-	1	-	-	-	-	-	-	-	1	1	2	-
CO4	3	2	2	2	1	-	-	-	-	-	-	1	3	-	-
CO5	3	-	-	-	-	-	-	-	-	-	-	1	3	1	2

Contents:

Basic Structure of Computers, Functional units, software, performance issues software, machine instructions and programs, Types of instructions, Instruction sets: Instruction formats, Assembly language, Stacks, Ques, Subroutines.

Processor organisation, Information representation, number formats.

multiplication & division ALU design, Floating Point arithmetic, IEEE 754 floating point formats

Control Design, Instruction sequencing, Interpretation, Hard wired control - Design methods, and CPU control unit. Microprogrammed Control - Basic concepts, minimizing microinstruction size, multiplier control unit. Microprogrammed computers - CPU control unit

Memory organization, device characteristics, RAM, ROM, Memory management, Concept of Cache & associative memories, Virtual memory,.

System organization, Input - Output systems, Interrupt, DMA, Standard I/O interfaces

Concept of parallel processing, Pipelining, Forms of parallel processing, interconnect network

Books

1. Computer Organisation,V.Carl Hammacher,Fifth Edition.
2. Structured Computer Organisation,A.S.Tanenbum,PHI,Third edition
3. Computer Organisation and Microprogramming,"Y.Chu, II, Englewood Chiffs, N.J.",Prentice Hall,Edition
4. Computer System Architecture,M.M.Mano,Edition
5. Computer Organisation and Programming,C.W.Gear,"McGraw Hill, N.V",Edition
6. Computer Architecture and Organisation,Hayes J.P,PHI,Second edition

ECL411 Digital Image Processing [(3-0-2); Credits: 4]

***Pre-requisite: ECL304**

Course Outcomes

1. To understand and explore importance of Digital Image Processing.
2. To extend the theory concepts of Digital Signal Processing further to Digital Image Processing.
3. To physically understand concepts of digital image enhancement and filtering in spatial domain.
4. To implement frequency domain filters for image processing applications.
5. To visualize basic computer vision algorithms using the learned Image Processing concepts.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	-	-	-	-	-	-	-	-	1	3	2	1
CO2	3	2	2	-	2	-	-	-	-	-	-	1	2	1	1
CO3	3	2	2	1	2	-	-	-	-	-	-	2	1	1	2
CO4	3	2	2	2	-	-	-	-	-	-	-	2	3	2	2
CO5	3	3	3	2	2	-	-	-	-	-	-	1	2	2	3

Contents

Elements of visual perception, Digital Image fundamentals, Basic image processing steps, Image Transforms, Image enhancement in spatial and frequeny domain, linear gray level transformations, Histogram equalization and specification ,smoothing & sharpening spatial filters, Image degradation models ,image restoration, inverse filtering, Wiener filtering. Image reconstructions from projections, radon transform, projection theorem of computerized tomography Morphological image processing ,dilation ,erosion, Basic morphological algorithms ,thinning algorithms Edge detection ,Edge linking & Boundary Detection ,watershed segmentation algorithm , Introduction to object recognition., colour image processing ,RGB and HSI color models, Gray level to color transformations

List of Experiments:

1. Write a program for some basic affine transform on images.
Rotation with 45 degree angle
Translation
Vertical shearing
Horizontal shearing

2. Write a program for
Take an image and insert alternate zeros in every row
Alternate rows should have shifted zeros and do averaging

3. Write a program capable of zooming and shrinking an image by pixel replication. Assume that the desired zoom/shrink factors are integers. Take any image and use your program to shrink the image by a factor of 10. Use your program to zoom the image back to the resolution of the original. Explain the reasons for their differences.

4. Enhance the image ‘spine.tiff’ (available in MATLAB), using
The log transformation
The power-law transformation
In (a) the only free parameter is c, but in (b) there are two parameters, c and r for which values have to be selected. By experimentation, obtain the best visual enhancement possible with the methods in (a)

and (b). Once (according to your judgment) you have the best visual result for each transformation, explain the reasons for the major differences between them.

5. Write a function to generate the histogram of an image. The function should take an image data array (with pixel values in the range 0 – 255) as its only parameter and return an array containing the histogram of the image. The histogram can be displayed using the built in plotting function.

6. Write a function to implement histogram equalization. Use it to enhance the images. Compare the output of your implementation with any built-in library function.

7. Load an image and then perform a simple spatial 3x3 average of image pixels. In other words, replace the value of every pixel by the average of the values in its 3x3 neighborhood. Be careful with pixels at the image boundaries. Repeat the process for a 10x10 neighborhood and again for a 20x20 neighborhood. Observe what happens to the image and give explanation for it.

8. (a) Write a program to add Gaussian noise to an image. You must be able to specify the noise mean and variance.
(b) Write a program to add salt-and-pepper (impulse) noise to an image. You must be able to specify the probabilities of each of the two noise components.

9. In given image there is a disturbing pattern, which should be removed. The pattern is a sinusoidal component. Remove the disturbance by looking in the frequency domain for the spike corresponding to the disturbing frequency and try to remove it from there. (Hint: The disturbing frequency can be found in the FFT by considering the orientation and frequency of the disturbance.)

10. Write your own code for some basic functions that work on binary images.
    a. dilation
    b. erosion
    c. opening
    d. closing

You are not allowed to use standard functions such as "BWMORPH".

Reference Books

1. Digital Image Processing Gonzalez R.C. and Woods R.E., Pearson, Second
2. Digital Image Processing Pratt W.K., Wiley, Third
3. Fundamentals of Digital Image Processing, A.K.Jain, PHI

ECL412 Advanced Digital Signal Processing [(3-0-2); Credits: 4]

***Pre-requisite: ECL304**

Course Outcomes

1. Study about the 2-Dimensional representation of signal and their operations
2. Understand the different 2-D transformation methods and their properties
3. Gain the knowledge about the application of multirate signal processing and different algorithms of filter design.
4. Consolidate the theoretical and mathematical formulation of different transformation methods (DCT, STFT, DWT).
5. Know role of adaptive filtering technique and implement the filtering concept using MATLAB and Simulink and research applications.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO2	3	-	-	-	-	-	-	-	-	-	-	-	2	2	-
CO3	3		1	-	2	-	-	-	-	-	-	-	2	2	3
CO4	3	1	1	-	-	-	-	-	-	-	-	-	3	1	1
CO5	3	2	2	-	3	-	-	-	-	-	-	-	3	2	3

Contents:

Representation of 2-dimensional signals and systems, 2-D extensions of DTFT, DFT, and Z-transform, Linear filtering of using DFT/FFT, Chirp Z-transform

Multirate signal processing, Decimation and Interpolation, Upsampling and Downsampling in Z-domain, Polyphase structure, Filter Design for Interpolator and Decimator, Multistage Decimator and Interpolator, Filter Banks, Uniform DFT filter Bank, and its polyphase realization, Two channel QMF filter Bank

Discrete Cosine transform, Short time Fourier Transform and its application on speech signals, Discrete Wavelet Transform, Multiresolution properties, implementation of DWT, wavelet packets, Application of DWT for signal and image denoising.

Introduction to Adaptive filter Design, Correlation and basic of linear Algebra, Wiener Filtering, Least mean square (LMS) algorithm, Block LMS, frequency domain adaptive filtering, linear prediction theory. Adaptive lattice filter design.

Lab Experiments:

1. Study of interpolation and Decimation
2. Implement all four different types of filter for a multiple sinusoidal signal having three different frequencies, amplitudes and phases corrupted with random noise.
3. Synthesis & Analysis of signal using STFT
4. Synthesis & Analysis of signal using DWT.
5. Implement using software tools to compute the DCT coefficients for a given signal.
6. Implement Least mean square algorithm using software tools
7. Implement using software tools to optimize the filter coefficients using steepest decent algorithm.

Books

1. S. K. Mitra “Digital Signal Processing: A Computer based Approach” 4th edition TMH
2. Rafael C. Gonzalez and Richard E. Woods, “Digital Image Processing”, Pearson Education 3rd Edition
3. Tamal Bose, Digital Signal and Image Processing, John Wlley & Sons, Inc
4. S. Haykin, “Adaptive Filter Theory”, 4th edition Prentice Hall

ECL408 Biomedical Engineering [(3-0-0); Credits: 3]

Course Outcomes

Students will

1. Study the human body functioning for the purpose of biomedical measurements
2. Understand the cardiovascular system, ECG, PCG signal acquisition and blood pressure measurement
3. Learn about the Nervous system and EEG, ERPs and EMG signal measurement and its characteristics.
4. Gain the knowledge about the medical imaging instruments and modalities
5. Learn the signal processing aspects of acquiring biomedical signal and images.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	1	3	-	-
CO2	3	-	-	-	2	-	-	-	-	-	-	-	3	-	-
CO3	3	-	-	-	2	-	-	-	-	-	-	-	3	-	-
CO4	3	-	-	-	2	1	-	-	-	-	-	-	2		-
CO5	3	-	-	-	-	1	-	-	-	-	-	-	2	-	2

Contents:

Anatomy and physiology, Sources of bioelectric potential (resting and action potential, Propagation of action potential, Bioelectric potential)

Biomedical signals and Electrodes: Nature of biomedical signal, Example of biomedical signals with the functioning of the organs, ENG, EMG, ECG, EEG, ERp, EGG, PCG, CP, Speech Signal, VMG, VAG Objective of Biomedial Signal analysis, Difficulties in analysis, Electrodes

Cardiovascular System, Heart anatomy, Cardiovascular measurement, Blood flow, Blood pressure measurement, Plethysmography, Heart sound, heart rate and pulse rate measurement, Nervous system, Anatomy, Measurement,Respiratory System, Measurement

Medical Imaging System, X-ray, CT, US, MR, SPECT, PET imaging

Therapeutic Equipment: Cardiac pacemaker. Defibrillators, Diathermy, Ventilators, Lithotriptors.

Books

1. “Biomedical Inst. & Measurement”, Cromwell, McGraw Hill
2. “Biomedical Phenomenon”, Plonsay Robert, McGraw Hill
3. “Biomedical Engg”, Khandpur, Tata McGraw Hill

ECL311 Automotive Electronics [(3-0-0); Credits: 3]

Course Outcomes

Students will

1. be able to identify various systems and sub-systems in automobiles
2. describe applications of electronics in various systems in automobiles
3. be conversant with various industry standards in automotive industry
4. be able to design embedded systems for automobiles
5. be familiar with advancements taking place in the field of automobiles

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	1	2	-	-	-	-	-	-	-	2	-	-
CO2	1	1	1	1	2	-	-	-	-	-	-	-	2	-	-
CO3	1	1	1	1	2	1	-	-	-	-	-	-	1	-	-
CO4	1	2	2	1	2	1	-	-	-	-	-	-	-	2	2
CO5	1	1	1	1	2	1	-	-	-	-	-	1	1	-	2

Contents:

Fundamentals:- Engines, Fuel systems, Steering, Suspension & braking system, Transmission system, passenger amenities like air conditioning ,anti-theft & safety systems.

Electrical systems in automobiles:- Charging , Alternators & motors &their applications ,wiring technology components , lightning systems ,dash board instruments.

Engine Control systems: - Microcomputer instrumentation &control, basics of electronic engine control, sensors, actuators, and digital engine control systems, engine mapping for optimum performance.

Vehicle motion control:- Antilock braking ,electronic power steering, advanced suspension automatic transmission, cruise control.

Integration of control systems:- Embedded real time controllers ,diagnostics, ISO 9141-2,vehicle networks CAN bus ,LIN,TTCAN & FTTCAN, hardware design using embedded controllers ,microprocessors and FPGA's.

Advances in automobile technology :- Navigation aids, driver information systems, anti-collision systems, intelligent transport systems, hybrid engine vehicles, alternative fuel technologies, emission control systems & regulations onboard diagnostics.

Books

1. William Ribbens, “Understanding Automotive Electronics” (6E)- Elsevier.
2. Bolton, “Mechatronics (3E)” Pearson.
3. Necsulescu, “Mechatronics” Pearson.
4. Crouse & Anglin, “Automotive Mechanics”,

ECL414 Electronic Product Design and Reliability [(3-0-0); Credits: 3]

Course Outcomes

Students will

1. Be familiar with process of defining product specifications
2. Be familiar with impact of various technical and non-technical aspects on product design
3. Be able to define goals of product design
4. Be able to identify factors affecting reliability of the product
5. Be conversant with data analysis methods for reliability improvement

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	2	-	-	-	-	-	-	-	-	1	1	-	-
CO2	3	2	2	1	2	-	-	-	-	-	-	1	1	-	-
CO3	-	3	2	2	-	-	-	-	-	-	-	1	1	-	1
CO4	2	1	3	3	-	2	-	-	2	-	-	1	1	2	-
CO5	2	3	3	2	-	1	-	-	1	1		1	-	-	1

Contents:

An introduction to electronic product design: Product development management, establishing needs and specifications, Exploiting the market opportunity

System design, costs and product development, Packaging, noise and heat management, Fundamentals of PCB and PCB design, Hardware design and testing methods, Product documentation Introduction to design for manufacture, design for testing

Design for reliability, Generic stress factors and de-rating, Selection and application of components Failure mode and effects analysis, failure data management and analysis Reliability evaluation of equipment

Books

1. V. S. Bangad, "Electronic Product Design",Technical Publications Pune
2. James Angus, Anthony Ward,"Electronic Product Design",CRC Press
3. R.G. Kaduskar, V.B. Baru,"Electronic Product Design",Wiley
4. Natarajan, Dhanasekharan, "Reliable Design of Electronic Equipment,An Engineering Guide",Springer
5. Norman B. Fuqua,"Reliability Engineering for Electronic Design",Jenson Books Inc.

ECL307 Statistical Signal Processing [3-0-0; Credits: 3]

***Pre-requisite: ECL211**

Course outcomes

1. After completing this course, the student must demonstrate the knowledge and ability to:
2. Understand the concepts of random signal processes.
3. Model the random processes.
4. Apply the concepts of random signals to Signal Processing and Digital Communications.
5. Develop simulation model for the random signals and processes.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	-	-	-	-	-	-	-	1	2	2	2
CO2	3	3	1	1	-	-	-	-	-	-	-	1	1	2	2
CO3	3	3	1	1	-	-	-	-	-	-	-	1	2	1	3
CO4	3	3	1	1	-	1	-	-	-	-	-	1	2	2	2
CO5	3	2	1	1	-	-	-	-	-	-	-	1	2	1	2

Contents:

Representation of random signal processes, Random variables and expectations, Random processes, Concept of Stationarity, Correlation and Covariances, Frequency domain representation of random signals, Weiner-Khinchin theorem, Ergodicity, Finite Dimensional representation of random processes.

Signal space Representation: Vector space concepts, Eigenvectors, Inner product spaces, Signal space representation, Discrete signal representation, Complete orthonormal sets.

Simulation methods for random processes, Monte-Carlo Simulations.

Text Books

1. L. E. Franks , “Signal Theory”, Prentice Hall.
2. Haykin, “Adaptive Filter Theory”, Pearson Education
3. Papoulis, ‘”Probability Theory and Random Variables”, Mc Graw Hill

Reference Books

1. Oppenheim, “Signals Systems, and Inference” , Pearson
2. Gallager, “Stochastic Processes” , Cambridge

CSL312 Concepts in Operating Systems [(3-0-0); Credits: 3]

Course Outcomes

Students will

1. know models of Operating Systems from the uni-processor and multiprocessor perspectives.
2. know frame of reference on which the existing designs have emerged and the future design possibilities are likely to evolve.
3. know paradigm that views an Operating System environment in the collective interplay of processes requiring economic resources.
4. gain knowledge about the Operating Systems concepts such as process, main memory management, secondary memory management, CPU and disk scheduling etc.
5. be aware of security issues in operating systems.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	2	-	1	-	-	-	-	-	-	1	3	-	-
CO2	3	2	3	2	2	-	-	-	-	-	-	1	3	2	-
CO3	2	2	2	2	-	-	-	-	-	-	-	1	3	-	-
CO4	3	3	3	2	-	-	-	-	-	-	-	1	3	-	-
CO5	2	2	2	1	2	1	-	1	-	-	-	1	2	-	2

Contents:

Introduction to Operating Systems, simple batch Systems, time sharing systems etc., computer system structures, I/O structure, storage structure, operating system structures, operating system services, system calls

Process management, Concept of a process, operations on a process, interprocess communication, CPU scheduling, scheduling criteria, scheduling algorithms, process synchronization, critical section problem, synchronization primitives, semaphores, monitors, deadlocks, deadlock prevention, avoidance and detection

Storage Management, memory management, logical vs. physical address space, paging and segmentation, virtual memory, demand paging, page replacement algorithms, thrashing

File system interface, file concept, access methods, directory structure, protection, file-system implementation, allocation methods, free-space management

I/O Systems, I/O hardware, secondary-storage structure, disk structure, disk scheduling, disk management

Protection and security, goals of protection, domain of protection, access matrix, capability based systems, security issues, authentication, encryption.

Books

1. Operating System Concepts,"Galvin P.B., Silberchatz A",Wesley
2. Operating Systems,Stallings W,"PHI, New Delhi"
3. Modern Operating Systems,Tanenbaum A.S,"PHI, New Delhi"

ECL420 Smart Antennas [(3-0-0); Credits: 3]

***Pre-requisite: ECL405**

Course Outcomes

Students will

1. Be acquainted with fundamentals and terminology of antenna arrays.
2. Be familiar with working of smart arrays.
3. Be able to utilize various signal processing techniques for smart arrays.
4. Be conversant with smart array implementation for different communication technologies and standards.
5. Be able to assess impact of channel characteristics on antenna arrays.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	1	-	-	-	-	-	-	1	3	2	2
CO2	2	1	-	-	1	-	-	-	-	-	-	1	3	2	2
CO3	2	3	3	2	2	-	-	-	-	-	-	1	3	2	2
CO4	2	2	3	3	2	-	-	-	1	-	1	1	3	2	2
CO5	2	2	3	-	2	-	-	-	-	-	-	1	3	2	2

Contents:

Array Antenna Fundamentals: Linear Arrays, Array Weighting, Beamsteered Arrays, Circular Arrays, Fixed Beam and Sectorized Arrays. Sidelobe Cancellors , Retrodirective Arrays. Smart Antennas, benefits of smart antennas, Adaptive Algorithm Basics , Gradient Based Methods, Howells Applebaum Processor, Adaptive Beamforming Elimination of the Effects of Mutual Coupling on Adaptive Antennas. Adaptive Arrays for CDMA, Waveform Diversity Methods, MIMO ExamplesAngle-of-Arrival Estimation, Array Correlation Matrix ,Bartlett AOA Estimation method ,Capon AOA Estimation method , Spectral Estimation Methods .Channel Characterization ,Channel Impulse Response, Slow Fading; Fast Fading; Fast Fading Modeling ,Spreading , Channel Equalization. Methods for Optimizing the Location of Base Stations for Indoor Wireless Communication, Identification and Elimination of Multipath Effects, Signal Enhancement in Multiuser Communication.

Books

1. Smart Antennas for Wireless Communications By Frank Gross, McGraw hill
2. Smart Antennas, Tapan A. Sarkar ,M. C. Wicks, M. Salazar-Palma, R. J. Bonneau , Wiley
3. Introduction to Smart Antennas , Balanis, Constantine A. , Morgan & Claypool

ECL429 Communication Networks [(3-0-2); Credits: 4]

*Pre-requisite:- Digital communication, Analog communication

Course Outcomes

Students will

1. Be able to distinguish between various network topologies and types of switching
2. Be knowing various medium access protocols and network hardware components
3. Be knowing details of network layer protocols IPv4 and Ipv6
4. Be familiar with various protocols used for network control, management and testing.
5. Be conversant with application layer of internet (web technology)

CO-PO mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	-	-	-	-	-	-	-	-	-	1	2	2	1
CO2	2	2	1	-	-	-	-	-	-	-	-	1	1	1	1
CO3	3	2	2	-	-	-	-	-	-	-	-	1	1	1	1
CO4	3	-	-	-	1	-	-	-	-	-	-	1	2	1	-
CO5	3	-	-	-	1	-	-	-	-	-	-	2	1	1	1

Contents:

Networks and services; network topologies; switching methods; network evolution; concept of layered architecture; the OSI model; the TCP/IP model; standardization and standards organizations.
circuit switching; space and time division switching; signaling methods; store-and-forward switching.

Access networks and backhaul networks , LANs and MAC protocols; ALOHA, slotted ALOHA, CSMA and CSMA-CD protocols; IEEE802.3 protocol and MAC frame format. Details of 802.3 hardware options; 100 Mbps and 1000 Mbps Ethernet LANs, switches, bridges and VPN; Wireless LANs; LAN applications; Bluetooth

Network Layer: services offered to the transport layer, internal organization as datagram or virtual circuit subnets; routing algorithms; congestion control; internetworking; Study of Ipv4 and IP v6, DNS and Internet routing protocols.

Transport Layer: Design issues; study of TCP; connection setup and removal; flow control; reliable and efficient delivery, timer management. The TCP/IP protocol stack: ICMP, IGMP, UDP, BOOTP, DHCP etc.

Network applications: World Wide Web and HTTP; HTTPs, Web servers and browsers, Content Engines; FTP and TFTP; SMTP and MIME; DNS.

Books**:**

1. Communication Networks ; Leon-Garcia and Widjaja TMH 3e
2. Computer Networks, a systems approach Peterson and Davie- Morgan Kauffman, Harcourt
3. Computer Networks , Tanenbaum A. S.; PHI, 4e,
4. Data Comuncation and Networking , B. Forouzan, TMH ,4e
5. Data and Computer Communication, Stallings William, PHI, 6e
6. Computer Networking, a top-down approach featuring the Internet; Kurose and Ross ; Addison Wesley, (Low Price Edition)

7. Communications and Networking Technologies- Gallo and Hancock ;Thomson Learning

List of experiments:

1. To study various network commands using Command Prompt
2. To study various network topologies of the network using Cisco Packet Tracer
3. Configure a network using Static Routing using Cisco Packet Tracer
4. Configure a network using Dynamic Routing using Cisco Packet Tracer
5. To configure router via CLI Commands using Cisco Packet Tracer
6. To configure a network via DHCP with sever or router using Cisco Packet Tracer
7. Illustration of utilization of DNS and Web server in a network using Cisco Packet Tracer
8. Study and implementation of TCP using Tetcos Netsim
9. Implementation of OSPF and RIP protocol using Tetcos Netsim
10. Study of CSMA-CD using Cisco packet tracer
11. Study of crimping tool

ECL430 Biomedical Signal Processing [3-0-2; Credits: 4]

***Pre-requisite:- ECL304**

Course Outcomes

1. Gain the knowledge about the origin of bio-potentials.
2. Understand the basic research challenges involve in different biomedical signals monitoring and their analysis
3. Realize the different filter design concepts required for biomedical data
4. Study the applications of different signal processing methods on biomedical field. .
5. Carry out the spectral analysis to evaluate the electroencephalographic biosignals and heart rate variability.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	1	1	-	-
CO2	3	2	-	-	-	-	-	1	-	-	-	-	3	2	-
CO3	3	2	1	-	-	-	-	1	-	-	-	1	2	3	2
CO4	3	2	1	-	-	-	-	1	-	-	-	1	3	2	1
CO5	3	1	-	2	-	-	-	2	-	-	-		2	3	1

Contents:

Preliminaries, Biomedical Signal Origin and dynamics of ECG, EEG, EMG, PCG, VMG, VAG, etc., Challenges in Physiological signals monitoring and analysis

Cardiological Signal Processing: ECG parameters and their estimation; Use of multi-scale analysis for parameters estimation of ECG waveforms, Adaptive noise canceller, Event Detection.

Correlation and coherence analysis of EEG channels, Detection of EEG spike and wave complexes, Morphological analysis of ECG waves, Time domain filters, Frequency domain Filters, Principles of adaptive filters, Wiener Filtering- Steepest Descent algorithms, Least mean square adaptive algorithms, Adaptive noise canceller- Interference cancellation in Electrocardiography- noise cancellation in electro surgery.

HRV and Arrhythmia analysis, Time domain and spectral domain parameters of short term recording.

Neurological Signal Processing: Brain and its potentials, Electrophysiology origin of brain waves, EEG Signal and its characteristics, EEG analysis, Linear prediction theory, The autoregressive (AR) method, Transient detection and elimination-the case of epileptic patients.

List of experiment

1. ECG signal acquisition: To study the ECG Acquisition by Lead II, data collection and wave shape of ECG signal
2. EEG signal acquisition: To study 10-20 electrode system and wave shapes of EEG signals and its different frequency components.
3. Filter design: To implement different filtering techniques to remove different artifacts and noise.
4. ECG feature extraction and analysis: To detect and estimate various features of ECG signal and wave components.
5. Frequency domain analysis of biomedical signals
6. Coherence Analysis
7. Detection of Spike-and-wave Complexes in EEG Signals
8. Case study: Data analysis and signal processing with standard data set of ECG signal

Books

1. Reddy D C. “Modern Biomedical Signal Processing – Principles and Techniques”, TMH, New Delhi, 2005
2. Tompkins W J “Biomedical Signal Processing”, PHI
3. Rangaraj M. Rangayyan, “Biomedical Signal Analysis: A case study Approach”, Wiley
4. Akay M. “Biomedical Signal Processing”, Academic press
5. Bronzino J D “The Biomedical Engineering handbook”, CRC and Free press, Florida, 1995.
6. Arnon Cohen “Biomedical Signal Processing” CRC Press.

ECL443: Machine Learning with Python (3-0-2; Credits: 4)

Course Outcomes

Student will learn

1. to implement different artificial neural networks for solving different problems with python
2. to employ various convolution neural networks for solving different problems with python
3. to design unsupervised learning algorithms like PCA and autoencoders for solving different problems using python
4. to employ different complex algorithms to handle time series analysis like recurrent neural networks
5. to implement different deep networks using dedicated low cost embedded systems

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	1	3	-	-	-	-	-	-	1	3	1	2
CO2	2	2	3	1	3	-	-	-	-	-	-	1	3	1	2
CO3	2	2	3	1	3	-	-	-	-	-	-	1	3	1	2
CO4	2	2	3	1	3	-	-	-	-	-	-	1	3	1	2
CO5	1	2	3	2	3	-	-	-	-	-	-	1	3	1	2

Content:

Penalized and generalized linear models: Logistic regression, L1 and L2 penalization, application to high dimensional low sample size problems.

Introduction to artificial neural networks [ANNs]: Artificial neuron, single hidden layer, multiple hidden layer, back propagation, momentum, loss functions, relation with support vector machines and penalized logistic regression. Implementation of ANNs for different classification and regression problems using python.

Convolutional neural networks: Convolutional layers, pooling layers, drop out, VGGnet, inception modules, residual networks, deconv nets. Applications to object recognition. Implementation of different CNNs for supervised classification in python.
Why deep learning works: Role of depth, closeness of local minima to global minimal, predominance of saddle points and ridges vs. local minima.
Autoencoders, Autoencoders and Principle component analysis, variants of autoencoders, generative adversarial networks, Implementation of different autoencoders in python.
Recurrent neural networks [RNN] and LSTMs: lateral connections, Transformers, applications to NLP, vision transformers, Implementations of RNNs using python [Tensorflow]
Implementation of different machine learning algorithms using low cost dedicated embedded systems.

List of Laboratory Experiments

1. Introduction to supervised learning framework
2. Implementation of basic supervised learning algorithms like linear regression.
3. Design and implementation of an artificial neural network for solving a supervised learning problem.
4. Implementation of Support Vector Machine
5. Implementation of auto encoders and Principle Component analysis for dimensionality reduction.
6. Implementation of auto encoders for clustering.
7. Design and implementation of a convolutional neural network

8. Implementation of Recurrence neural networks
9. Implementation of pre trained convolution neural networks for classification
10. Implementation of trained objet detection algorithm with Jetson Nano board.

Text Book:

1. Bishop, Pattern Recognition and Machine Learning, Springer, New York, NY
2. Deep Learning by Goodfellow, Bengio and Courville.

Reference Book:

1. Probabilistic Graphical Models: Principles and Techniques by Koller and Friedman.

ECL423 Image Analysis and Computer Vision [(3-0-2); Credits: 4]

***Pre-requisite: ECL304**

Course Outcomes

Students will

1. Learn about the difficulties associated with automated image content recognition and understand the imaging issues from the perspective of quantitative image analysis.
2. Know a broad range of computer vision techniques and apply methods that are most relevant to their research.
3. Know computer vision algorithms, methods and concepts which will enable the student to implement computer vision systems with emphasis on applications and problem solving.
4. Have in-depth understanding of human vision system with its usefulness in development of machine vision algorithms by looking at stereoscopic(3D) vision systems.
5. Be able to apply the knowledge imparted to develop a computer vision system.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	2	2	2	1
CO2	3	1	1	-	1	-	-	-	-	-	-	1	3	2	2
CO3	3	1	1	1	-	-	-	-	-	-	-	-	3	3	3
CO4	3	-	-	-	-	-	-	-	-	-	-	1	3	2	2
CO5	3	2	2	1	1	-	-	1	1	-	-	2	1	2	3

Contents:

Introduction to computer vision: What is computer vision, advantages and disadvantages of computer vision, general applications of computer vision.

Data structures for Image Analysis: Levels of data representation, Traditional and Hierarchical structure.

Feature detection and matching: Points and patches, edges, lines,

Segmentations: Feature based alignment: 2D and 3D feature based alignments algorithms and applications, Pose estimation Techniques.

Computational imaging: super resolution, blur removal, image matting and compositing, texture analysis and synthesis, stereo imaging, basic concepts, and applications.

3D image processing techniques: basics of 3D images, 3D sensing, camera calibrations, and reconstructions, 3D from 2D image, surface based representations, point based representations, and volumetric based representations, and model based reconstruction, recovering textures from 3D images and applications of 3D imaging techniques, 3D shape recognition. Uses of 3D vision: Shape from X, 3D model based vision.

Object Recognition techniques: Knowledge representation, statistical pattern recognition, Neural Nets, Syntactic pattern recognition, optimization techniques in recognition, Fuzzy based systems for recognition.

Digital Video Processing: Introduction, video segmentation and tracking, change detection, motion segmentation and tracking, Video Filtering: Introduction, format conversion, Multiframe noise filtering and restoration, Multi frame super resolution,

Motion estimation: Differential motion analysis methods, optical flow, detection of specific motion patterns, image stitching, motion models for tracking, alignments, compositing.

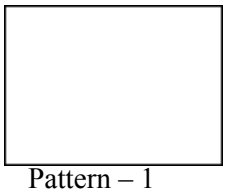
Image and video Compression techniques.

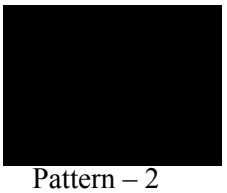
Case studies of computer vision projects such as content-based image retrieval, face recognition, video surveillance etc.

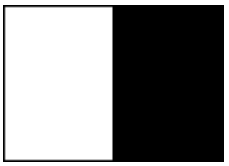
List of Experiments

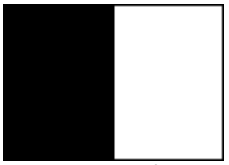
Phase-I:

1. Understanding **basics of images** and understanding of **2D signal handling** by generation of various patterns


Pattern – 1

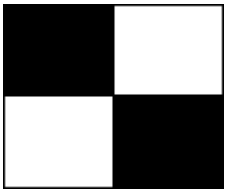

Pattern – 2

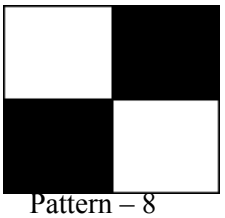

Pattern – 3

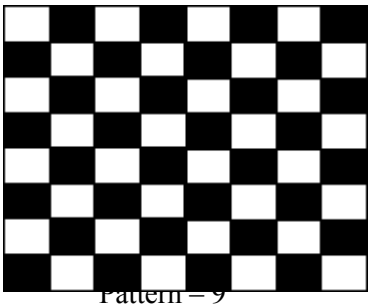

Pattern – 4


Pattern – 5


Pattern – 6


Pattern – 7


Pattern – 8


Pattern – 9

2. Performing simple **arithmetic operations** on images (Take Lena and Cameraman images)
   - i) Add a constant
   - ii) Subtract a constant
   - iii) Multiply a constant
   - iv) Divide a constant
   - v) Addition of two images
   - vi) Subtraction of two images
   - vii) Multiplication of two images
   - viii) Division of two images.

3. Perform **specific intensity search** operations on images (Take Lena and Cameraman Image)

4. Perform **Edge, point and line detection** operations on images.

5. **Image fusion** in spatial domain (Take Lena and cameraman image and perform the operation).

6. **Image Thresholding:** Apply the following thresholds on Lena and cameraman images and compare the results

7. **Image segmentation**: Understanding and implementation of various Image segmentation methods.

Phase-II:

8. **DCT**: Apply Discrete Cosine Transform (DCT) on two the images. (Take cameramen and Lena images)

9. **IDCT:** Apply Inverse Discrete Cosine Transform (IDCT) on the image. (Take cameramen and Lena images)

10. **Image Compression and Decompression:** Perform image compression and decompression using JPEG.

11. **DWT:** Apply Discrete Wavelet Transform (DWT) on two the images. (Take cameramen and Lena images)

12. **IDWT:** Apply Inverse Discrete Wavelet Transform (IDWT) on the image. (Take cameramen and Lena images)

13. **EZW:** Implement Embedded Zero Wavelet (EZW) algorithm on Images.

14. **Image Compression and Decompression:** Perform image compression and decompression using DWT (JPEG 2000).

15. **Color Image Processing:** Perform the following operations on color images (Take RGB color images)
    - i) Color Replacement
    - ii) Color Detection
    - iii) Change of planes
    - iv) Color Space Transformations

Phase-III:

16. **Video Processing:** Operations on gray scale videos
    - i) Extracting frames from videos
    - ii) Playing video in reverse
    - iii) Applying background subtraction, frame differencing algorithm. (Take Video traffic Video)

17. **Video Processing:** Operations on Color videos
    - i) Extracting frames from videos and dealing with color video frames
    - ii) Playing video in reverse
    - iii) Applying background subtraction, frame differencing algorithm.

18. **Motion Estimation:** Understanding and implementation of motion estimation techniques used in videos.

19. **Video Compression and decompression:** Perform video compression and decompression mechanisms.

20. **MRA:** Perform Multi Resolution Analysis (MRA) on images and videos.

21. **Image Sharpening:** Understanding and implement Image Sharpening algorithms.

22. **Image and Video Watermarking:** Study and Implement any one of the watermarking algorithm on image and video.

23. **Image Stitching:** Understanding and implement Image Stitching algorithms.

Phase-IV:

24. **Image Matting:** Understanding and implement Image matting algorithms.

25. **Object Detection:** Study and Implement the object detection method on videos for detecting the stationary and moving objects.

26. **SIFT/SURF:** Study about SIFT/SURF and implement any one of the method.

27. **Stereo Imaging:** Understanding and implement Stereo Imaging.

28. **Computer Vision Applications:** Study and implement at least one method for Content based image retrieval.

29. **Computer Vision Applications:** Karhunen – Loeve Transform (KLT) based face representation and recognition system.

Computer Vision Applications: Study and implement at least one method for video surveillance, human tracking, vehicle tracking, etc.

Text Books

1. Richard Szeliski Springer, “Computer Vision: Algorithms and Applications”, 2010
2. Shapiro and Stockman, “Computer Vision”, Prentice Hall, 2001
3. Sonka, Hlavac, and Boyle Cengage Learning, “Image Processing, Analysis, and Machine Vision”, 2009.

Reference Books

1. Harley R. Myler, “Fundamentals Of Machine Vision”, PHI Learning (2003)
2. Forsyth, David A., Ponce, “Computer Vision: A Modern Approach”, Jean PHI Learning (2009)
3. Earl Gose Steve Jost and Richard Johnsonbaugh, “Pattern Recognition and Image Analysis”, PHI (2009)
4. Anil K. Jain, “Fundamentals of Digital image processing”, PHI, 2010
5. Rafael C. Gonzalez and Richard E. Woods, “Digital image processing”, Pearson Education 3rd Edition.

ECL413 Adaptive Signal Processing [(3-0-2); Credits: 4]
***Pre-requisite: ECL211**
Course Outcomes

1. To apply the basic concepts related to vector space and Eigen analysis
2. To understand the basic concept of stochastic signals and statistics of signals
3. To implement Wiener filter using LMS algorithms
4. To analyze and implement RLS algorithm
5. To design adaptive filters for real life applications

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	-	-	-	1	1	1	-	1	1	-	-
CO2	3	3	2	1	-	-	-	1	1	1	-	1	2	1	-
CO3	3	3	3	1	-	-	-	1	1	1	-	-	2	2	2
CO4	3	3	3	1	-	-	-	1	1	1	-	-	2	2	1
CO5	3	3	3	2	-	-	-	1	2	1	-	1	2	3	3

Contents:
Vectors, Matrices and Eigen Analysis. Application to adaptive signal processing. Stochastic Processes, Ensemble average, mean, average power, auto and cross correlation functions, stationarity and white noise, Auto-regressive process, modeling of physical processes. Least Squares and LMS algorithms, Normal equations, properties. Eigen System decomposition. Gradient search technique, convergence properties of LMS. Normalized LMS algorithm. Recursive solution techniques, RLS algorithm. Application to noise cancellation in real life examples,

Experiments:

1. Computation of mean, standard deviation, correlation function, correlation matrix, covariance matrix and power density of a stochastic process
2. Testing bias and consistency property of sample mean and sample variance
3. Modelling AR process of different orders
4. Modelling MA process of different orders
5. Noise cancellation using LMS algorithm
6. Investigation of the role of step size on convergence and mean square error for normalized LMS and block LMS algorithms
7. Investigation of the role of step size on convergence and mean square error for normalized LMS algorithm
8. Noise cancellation using normalized LMS and block LMS algorithms
9. Implementation of RLS algorithm for noise cancellation
10. Complexity and efficiency analysis of RLS algorithm

Text Books

1. S. Haykin Adaptive Filter Theory Fourth Edition Prentice Hall
2. B. Widrow and S. D. Sterns Adaptive Signal Processing Pearson Education

Reference Books

1. M. J. Larrimore, C. R. Johnson and J. R. Treichler Theory and Design of Adaptive Filters publisher

ECL439 Wireless Communications [3-0-0; Credits: 3]

***Pre-requisite: ECL303**

Course outcomes

Students will be able to

1. choose appropriate propagation model for a given environment
2. make a radio network plan for a given system
3. describe the interplay of system parameters of wireless communication methods
4. describe the interplay of system parameters of medium access methods
5. describe the trade-off of system parameters of diversity techniques

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	1	-	-	1		2	3	3	3
CO2	2	3	3	3	2	1	1	-	-	1		2	3	3	3
CO3	3	2	2	1	-	-	-	-	-	-	-	1	2	2	1
CO4	3	2	2	1	-	-	-	-	-	-	-	1	2	2	1
CO5	3	2	2	1	-	-	-	-	-	-	-	1	2	2	1

Contents:

Introduction to wireless digital communication systems; block diagram of a typical RF transceiver, radio propagation and cellular engineering concepts; frequency reuse, frequency management and channel assignment, handoff and handoff strategies, trunking theory, coverage and capacity improvements

Wireless Mobile Communication channel characterization: large scale path loss, free space propagation model, propagation effects such as reflection, diffraction, scattering etc. Outdoor and indoor propagation models, ray tracing and coverage prediction.

Small scale fading effects: time-variant impulse response model, channel correlation functions and spectral densities, coherence time, coherence bandwidth, channel models for Rayleigh, Ricean and Nakagami fading.

Modulation methods: Review of binary modulation methods; ASK, PSK and FSK; Quadrature modulation methods QPSK, QAM, MSK, GMSK, applications of differential coding, OFDM, MIMO, massive MIMO

Spread Spectrum methods: basics; generation and properties of PN sequences, DS-SS system analysis; slow and fast FH-SS system; performance analysis.

Medium access techniques, FDMA, TDMA, CDMA, SDMA. Introduction to non-orthogonal multiple access.

Books

1. Wireless Communication: Principles and Practices (2e) – Theodore Rappaport- Pearson Education.
2. Wireless Digital Communication- Feher- PHI
3. Digital communication (4e)- John Proakis, Tata- McGraw-Hill
4. Communication systems (4e) – Simon Haykin, Wiley

ECL437 Fundamentals of Information Theory [3-0-0; Credits: 3]

***Pre-requisite: ECL303**

Course outcomes

1. After completing this course, the student must demonstrate the knowledge and ability to:
2. analyze the self and mutual information.
3. evaluate the information rate of various information sources.
4. design lossless data compression codes for discrete memory-less sources.
5. evaluate the information capacity of discrete memory-less channels and determine possible code rates achievable on such channels.and design simple linear block codes.
6. select or design simple convolutional codes.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	-	2	1	-	-	-	-	-	-	-	3	2	3
CO2	3	3	1	3	1	-	-	-	-	-	-	-	2	2	2
CO3	3	3	3	3	1	-	-	-	-	-	-	-	2	3	3
CO4	3	3	1	3	1	-	-	-	-	-	-	-	2	2	2
CO5	3	3	3	3	1	-	-	-	-	-	-	-	2	3	3

Contents:

Communication channel, Channel matrix, Probability relation in a channel, the measure of information, Entropy function – Properties of entropy function, relative entropy, differential entropy, Mutual Information, Symmetry of information, Jensen's Inequality, Fano's Inequality.

Channel capacity; Special types of channels and their capacity, Noiseless channels symmetric channel, erasure channels, continuous channels, Shannon's theorem, Shannon Hartley theorem for AWGN channels.

Source and Channel Coding Methods, Block code, Binary code, Binary Huffman code, Shannon–Fano Encoding procedure, Noiseless coding theorem. Error – correcting codes such as linear block codes an convolutional codes.

Introduction to advanced codes like LDPC, Turbo codes etc.

Text Books

1. T.M.Cover and J.A Thomas, "Elements of information theory", John Wiley and Sons.
2. S .Haykins, " Communication Systems" John Wiley and Sons.
3. A.S. Gandhi, "Analog and Digital Communication", CRC Press.

Reference Books:

1. G. A. Jones et. Al, "Information and Coding Theory", Springer – Verlag.
2. J. H. van Lint, " Introduction to Coding Theory", Springer –Verlag.

ECL424 Optical Communication [(3-0-2); Credits: 4]

Course Outcomes

1. Familiarity with basic concepts and theory of Optical Communication.
2. Ability to demonstrate OPCOMM components, assemble them and solve problems on Optical Communication system.
3. Ability to design, implements, analyzes and maintains optical communication system
4. Knowledge of different source of light as well as receiver nd their comparative study
5. To get idea about power budget and ultimately be an engineer with adequate knowledge in optical domain

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	-	-	-	-	-	-	1	3	2	1
CO2	3	2	2	1	2	-	-	-	-	-	-	2	3	2	1
CO3	2	2	2	1	2	-	-	-	-	-	-	2	2	1	1
CO4	2	2	2	2	2	-	-	-	-	-	-	2	1	1	2
CO5	2	2	2	1	2	-	-	-	-	-	-	2	1	1	2

Contents:

Optical Fiber: Basic concepts of optical communication. The nature of light. Light as an Electromagnetic Wave, Polarisation, Interference. Transmitting light on a Fibre Refractive index, Fibre refractive index profiles, Modes of propagation. Light Propagation in Multimode Fibre, Snell's Law Critical Angle, Numerical aperture.

Optical Sources: Light Emitting Diodes (LEDS), The Semiconductor Junction Diode, Construction and Operation of LED's , Heterojunctions (Practical LED's) , Characteristics of LED'S, Lasers, Principle of the LASER, Semiconductor Laser Diodes.

Optical Detectors: Photoconductors, Photodiodes, P-N Diodes, P-I-N Diodes, Schottky-Barrier Photodiodes, Avalanche Photodiodes (APDS), Hetero-interface Photodetectors, Travelling Wave photo detectors, Phototransistors.

Optical Communication Systems: Point-to-point Transmission Systems, Modulation techniques, On-off key, Multi state coding, Forward Error correction, Receiving the signal, Timing recovery, Bandwidth Occupancy.

List of Experiments:

1. Measurement of propagation losses in an Optical Fiber
2. Measurement of Numerical Aperture of an Optical Fiber using 660 nm LED
3. Study of V-I , I-P characteristics of laser and V-I characteristics of 660 nm LED
   a. Study of Fiber optic transmission sensor
   b. Study of Fiber optic reflection sensor
   c. Transmission of light through fiber with gaps
4. Setting up of Fiber optic digital link
5. Setting up of Fiber optic analog link
6. Study and measurement of Bit Error Rate (BER)
7. Study of Pulse width modulation and demodulation
8. Study of Pulse amplitude modulation and demodulation
9. Study of Pulse position modulation and demodulation

Text Books:

1. Optical Fibre Communication Practice and Principles, J. Senior
2. Fibre Optic Communication , D. C. Agrawal
3. Optical Communication, Keiser

ECL314 Power Electronic Devices and Circuits [(3-0-0); Credits: 3]

***Pre-requisite: ECL308**

Course Outcomes

1. Know concepts of power electronic devices as switches
2. Understand operation and applications of converters
3. Comprehend operation of inverters and commutation methods
4. Learn techniques of PWM inverters
5. Understand operation of choppers

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	-	-	-	1	3	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	2	2	-	-
CO3	2	3	3	1	-	-	-	-	-	-	-	2	-	1	1
CO4	2	3	2	2	-	-	-	-	-	-	-	1	-	1	-
CO5	3	3	3	1	-	-	-	-	-	-	-	-	-	1	1

Contents:

Semiconductor devices used in power electronics: SCR, ASCR, RCT, LASCR, TRIAC, IGBT, Power MOSFET, GTO, Triggering devices: UJT, PUT, construction characteristics, ratings,

Thyristor as power controller, phase angle control, Extinction angle control, Symmetrical angle control, time ratio control, pulse width modulation, Turn on methods: Circuits for single phase line communicated converter, single phase converter, single phase inverter Turn off (commutation) Methods: type A, B, C, D, E and F.

Uncontrolled Rectifiers: single phase: (M-2), (B-2), (M-3), B-6; Single phase/three phase half control(one quadrant operation); Single phase full wave converter, Three phase converter, three pulse, six pulse, (Bridge type), Semi converter, Dual converter operation, Single phase bridge, three phase bridge (circulating & non circulating).

Invertors: Types-series, parallel, bridge, PWM voltage source inverter (CSI), Current source inverters (CSI), Filters-Types, calculation. Commutations methods,

Choppers: Circuits and operations.

Text Books

1. Sen P. C.; Morden Power Electronics; Wheeler Publishers, 1998.
2. Singh. M. G., K.B. Khanchandani; Power Electronics; Tata MaGraw Hill, 2000.

Reference Books

1. Bose. B. K.; Modern Power Electronics and AC Drives; Pearson education India, Indian Reprint, 2003.
2. Ned Mohan, et. al; Power Electronics; John Willey, 2000. Lander C. Y; Power Electronics: McGraw Hill International, 1993

ECL407 Radar Engineering [(3-0-0); Credits: 3]

***Pre-requisite: ECL404**

Course Outcomes

1. To understand the basic concepts related with radar technology.
2. To understand various components and various antenna mechanism used for radar technology.
3. To know specific use of technology for various requirement.
4. Ability to design radar transmitter and receiver system
5. Ability to design, implements and analyse a radar system.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	-	-	-	-	-	-	-	1	3	2	1
CO2	3	2	2	1	-	-	-	-	-	-	-	1	2	2	1
CO3	3	2	2	1	-	-	-	-	-	-	-	1	2	2	2
CO4	2	2	3	2	-	-	-	-	-	-	-	3	1	1	1
CO5	2	2	3	2	-	-	-	-	-	-	-	3	2	1	1

Contents:

Radar range equation, CW and EM modulated radar.
Moving target, Indicated and pulse Doppler radar, Tracking radar.
Transmitters, Magnetron Oscillator, Modulators, Line Pulsing modulator.
Radar receiver, Receiver noise, Extraction of information from radar.
Radar Antennas, Parabolic reflector, Scanning feed, Reflector assegrain, Lens Antennas.
Radar Clutter and interference-Radar Indicators.

Text / Reference Books

1. Introduction to Radar System,Skolink,McGraw HillEdition
2. Principles of Radar,Heities & Coates,McGraw HillEdition
3. Introduction to Radar System,Kingsley,McGraw HillEdition

ECL410 Satellite Communication [(3-0-0); Credits: 3]

***Pre-requisite: ECL303**

Course Outcomes

Students will

1. Be conversant with orbital aspects of satellite communication
2. Be able to design satellite link
3. Be knowing about digital satellite links
4. Be familiar with multi-access schemes
5. Be familiar with earth station technology

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	1	2	1	0
CO2	1	3	1	-	-	-	-	-	-	-	-	1	1	1	2
CO3	3	1	2	2	-	-	-	1	-	-	-	1	1	1	1
CO4	2	2	1	-	-	-	1	-	-	-	-	1	2	2	1
CO5	2	2	2	-	-	-	1	-	-	-	-	1	2	3	2

Contents:

Orbital aspects of satellite communication, Orbit mechanisms, Equation of orbit, Locating satellite in orbit, Orbital elements, Orbital area coverage, Look angles, Slant range,

Space craft subsystems, Attitude and orbit control system, Telemetry tracking and command system (TTC), Power subsystems, Antennas, Reliability

Satellite link design, System noise temperature, G/T ratio, Down link design, Uplink design, Link for specified (C/N) base-band noise signal.

Digital Satellite Links, Frequencies and channel allocations, Modulation techniques, QPSK, QAM, BER analysis, medium access methods for satellite communication.

Earth station technology, Earth station design for low system noise temperature. Equipment for earth stations, LNA and HPA.

VSAT systems- overview of VSAT systems, Access control protocols, multiple access selection, modulation, coding and interference issues .

Books

1. Satellite communication , Timothy Pratt, Charles Bostian, Jeremy Allnut, John Willey and Sons Inc. Second edition
2. Satellite Communication Systems Engineering, W. L. Pritchard, H.G. Suyderhoud, R.A. Nelson, Pearson Education Second edition
3. Advanced Electronic communications, Wayne Tomasi, Prentice Hall of India Pvt. Ltd Fifth edition
4. Electronic Communication Systems Frank.R. Dungan, International Thomson Publishing Company Third edition.
5. Satellite Communication Technology , Dr. K. Miya, Second edition

ECL436 Optimal Systems [(3-0-0); Credits: 3]

***Pre-requisite: ECL312**

Course Outcomes

1. To familiarize with the concept of optimal control of continuous time and discrete time systems.
2. Transform systems into state-space equation and apply the required optimality conditions.
3. Solve the optimal control problems using the vibrational approach.
4. Able to model and solve linear regulator problem.
5. Use the dynamic programming and the associated Hamilton-Jacobi-Bellman equation to solve linear quadratic control problems

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	1	2	2	3
CO2	3	3	2	-	-	-	-	-	-	-	-	-	1	1	2
CO3	3	2	2	-	-	-	-	-	-	-	-	-	1	1	3
CO4	3	2	2	-	-	-	-	-	-	-	-	1	1	1	1
CO5	3	2		-	-	-	-	-	-	-	-	-	1	1	2

Contents:

Definitions of Optimal Control, plant, Performance Index, constraints, formulation of optimal control problem, selection of a performance index

Formulation of Optimal control problem, the characteristic of the plant, minimum time problem, minimum energy problem, minimum fuel problem, state regulator problem, tracking problem

Calculus of variations, Optimum of a Function and a Functional, The Basic variational Problem, Fixed-End Time and Fixed-End State System, Euler Lagrange Equation, Different Cases for Euler-Lagrange Equation, Hamiltonian method, Steepest Descent method

Finite-Time Linear Quadratic Regulator, LQR System for General Performance Index, Analytical Solution to the Matrix Differential Riccati Equation, Infinite-Time LQR System, Stability Issues of Time-Invariant Regulator, Linear Quadratic Tracking System: Finite Time Case, LQT System: Infinite-Time Case.

Variational Calculus for Discrete-Time, Discrete-Time Optimal Systems, Discrete-Time Linear State Regulator, Closed-Loop Optimal Control: Matrix Difference Riccati Equation

Pontryagin Minimum Principle, Dynamic Programming, Optimal Control of Discrete-Time Systems, Optimal Control of Continuous-Time Systems, The Hamilton-Jacobi-Bellman Equation, LQR System Using H-J-B Equation

Books

1. Kirk Donald E.,"Optimal Control Theory An Introduction", Dover Publication Inc, Mineola, New York. 2004
2. Naidu Desineni Subbaram,"OPTIMAL CONTROL SYSTEMS", CRC PRESS, Boca Raton London New York Washington, D.C. 2002
3. Sage A. P. and White C. C,"Optimum Systems Control", PranticeHall,Englewood Cliffs, N.J.

ECL421: Advanced Sensors and Instrumentation[(3-0-0); Credits: 3]

Course outcomes

Students will

1. Understand basics and operating principle of a few advanced sensors.
2. Understand the behaviour of various physical systems and model them using some advanced technology.
3. learn characteristics of different controllers.
4. have fundamental and some special knowledge in process automation in industries using
5. know basic process parameters that are applied in most processing industries for both measurement and control applications.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	3	-	2	-	-	-	-	-	-	1	1	2	1
CO2	2	-	2	-	2	-	-	-	1	-	-	2	2	1	1
CO3	2	3	2	2	-	-	-	-	-	-	-	1	1	1	1
CO4	2	2	-	1	3	-	-	-	1	-	-	1	1	1	2
CO5	1	-	2	-	-	-	1	-	-	-	1	1	1	2	3

Course Content:

Smart sensors: Definitions, Comparisons, Smart Sensor Interface Standards. Recent / Advanced trends in sensor technology MEMS Sensors Comparison with Past technologies. , Fabrication Techniques, Case study of MEMS Sensors.

Controllers: On-off controllers , Analog controllers, Digital controllers, Fuzzy controllers, Working Principle, Merits- Demerits, Typical Application Areas and comparisons. Controller tuning and system design, Optimal control theory, Case study of Temperature controller, Case study of position controller, Case study of fuzzy controller, Study of PLC and Micro controller based instrumentation Systems.

Basics of computer aided process control systems: Microcomputer based process control. I) A programmable logic controller ii) A distributed control system

Industrial communication system: Signals and noise in Measurement Systems, RS232,485 interface standard, The 4 to 20mA current loop –Parallel Interface -Introduction to HART, Fieldbus and PROFIBUS.

Soft sensing and Navigation: Sensor data fusion- Mathematical algorithms, Coordinate transformations, Rigid body motion,Localization and Tracking.

Reliability: Basic concepts- Hazard function-Reliabilities of series and parallel systems- System Reliability.

Text Books:

1. Jacob Fraden, “Handbook of Modern Sensors: Physics, Designs, and Application”’, Springer Science Business Media, Inc, 3rd Edition, 2004.
2. Julian W. Gardner and Vijay K. Varadan, Microsensors, MEMS, and Smart Devices, John Wiley Sons Ltd, 1st Edition, reprinted 2007.
3. Donald E. Kirk, Optimal Control Theory: An Introduction, Prentice-Hall networks series, 1970
4. Govil, A.K., “Reliability Engineering”, Tata McGraw -Hill, New Delhi,1983

Reference books:

1. Arthur Gelb, Applied Optimal Estimation, The Analytic Sciences Corporation, M.I.T. Press, 2001
2. Frank D. Petruzella, Programmable Logic Controllers, Glencoe McGraw Hill Second Edition,
3. M.Elwenspoek, R.Wiegerink, Mechanical Microsensors, Springer-Verlag Berlin Heidelberg, 2001
4. M.P. Groover, et.al., Industrial Robots: Technology, Programming and applications, McGraw Hill, 2nd indian edition, 2012.

MAL408 Statistical Analysis & Queuing Theory [(3-0-0); Credits: 3]

***Pre-requisite: MAL205**

Course Outcomes

Students will

1. Be exposed to importance of statistical analysis.
2. Be aware of waiting time models.
3. Be able to use Markov chains for analysis.
4. Be able to apply queuing theory models to real life situations
5. Be able to use curve fitting methods

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	-	-	-	-	-	-	-	1	2	-	-
CO2	3	3	2	3	-	-	-	-	-	-	-	1	1	-	-
CO3	3	3	1	3	-	-	-	-	-	-	-	1	-	2	-
CO4	3	3	1	3	-	-	-	-	-	-	-	1	-	-	3
CO5	3	3	2	3	2	-	-	-	-	-	-	1	-	1	-

Contents:

Testing of Hypotheses: Neyman Pearson theory of testing of Hypotheses: Some fundamental notions of hypotheses testing, Neyman Pearson lemma, unbiased and invariant tests, generalized likelihood ratio tests, Chi – Square test, t – tests, F – tests, Bayes and minimax procedures, methods of finding confidence intervals, unbiased and equivariant confidence intervals.

Stochastic Processes: Introduction, classification of stochastic processes, the Bernoulli process, the Poisson process, Renewal process, availability analysis, random incidence, renewal model of program behavior.

Discrete-Parameter Markov Chains: Introduction, computation of n- step transition probabilities, state classification and limiting distributions, distribution of times between state changes, irreducible finite change with A periodic states, the M/G/1 Queuing system, discrete parameter Birth-Death processes, finite Markov chains with absorbing states.

Continuous – Parameter Markov Chains: Introduction, the Birth and death process, other special cases of Birth –death Model, non Birth-Death processes, Markov chains with absorbing states.

Networks of Queues: Introduction, open queuing networks, closed queuing networks, non exponential service-time distributions and multiple job types, Non – product- Form Networks.

Regression , correlation and Analysis of Variance: Introduction, Least squares curve fitting, the coefficient of determination, confidence intervals in linear regression, correlation analysis, simple non linear regression, higher dimensional least squares fit, analysis of variance.

Books

1. Vijay K. Rohatgi& A.K. Md. EhsanesSaleh: “An Introduction to Probability and statistics” , John Wiley & Sons Inc., New York, 1976.

2. Kishor S. Trivedi : “Probability & Statistics with reliability, Queuing and computer Science applications”, PHI private Ltd, 2009.

ECL440 Cellular Systems [(3-0-0); Credits: 3]

***Pre-requisite: ECL303**

Course Outcomes

Students will

1. Describe the evolution of cellular systems and the key features of 1G to 5G and beyond.
2. Explain radio propagation models, antenna systems, and factors affecting signal coverage.
3. Analyze cell capacity, frequency reuse, and channel assignment strategies.
4. Apply handoff mechanisms, modulation techniques, and multiple access schemes in cellular networks.
5. Evaluate modern standards and emerging technologies like LTE, 5G-NR, SDR, mmWave, MIMO, and NOMA.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	-	1	1	1
CO2	3	-	-	-	-	-	-	-	-	-	-	1	1	1	2
CO3	3	-	-	-	1	1	1	-	-	1	-	2	2	2	2
CO4	3	-	-	-	-	1	1	-	-	-	-	2	3	1	1
CO5	3	-	-	-	-	1	1	-	-	-	-	2	3	1	1

Contents:

Introduction to cellular mobile systems, Evolution of Mobile Radio Communication, Basic Cellular System, Cellular Concepts, Generations of Cellular Systems, Overview of 1G, 2G, 3G, 4G, 5G, and beyond cellular systems.

Mobile Radio Propagation, Propagation Models, Antenna Systems.

Cell coverage for signal and traffic, Signal Coverage, Traffic Capacity, Diversity Techniques.

Frequency Management: Discussing numbering and grouping of channels, managing setup, access and paging channels.

Channel Assignment Strategies, Sectorization.

Handoffs and dropped calls, Handoff Initiation, Types of Handoff, Handoff Strategies, Dropped Call Rates.

Modulation Techniques, Speech and Channel Coding, Multiple Access Techniques.

Modern Cellular Standards: GSM, CDMA, GPRS, EDGE, UMTS, and LTE, 5G-NR, architectures, protocols, and key features.

Emerging Technologies, Software Defined Radio, mmWave, UAV as flying base station, NOMA, and Multiple-Input Multiple-Output (MIMO) technology.

Books

1. The Mobile Communications Handbook *by Jerry D. Gibson, Second or Third Edition*
2. Wireless Communications: Principles and Practice *by Theodore S. Rappaport.*
3. Mobile Cellular Telecommunications: Analog and Digital Systems, *by William C. Y. Lee.*

ECL409 Radio Frequency Circuit Design [(3-0-0); Credits: 3]

***Pre-requisite: ENL302**

Course Outcomes

Students will

1. be able to design passive matching networks.
2. describe RF amplifier design process in general
3. be able to design LNA, PA for a specified application.
4. design other circuits such as mixer, oscillator and phase locked loops
5. be able to select A/D and D/A converters for RF applications

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	1	-	-	-	-	-	-	1	2	2	2
CO2	3	2	3	2	1	-	-	-	-	-	-	1	3	2	2
CO3	2	3	3	2	1	-	-	-	-	-	-	1	2	3	3
CO4	2	3	3	2	1	-	-	-	-	-	-	1	2	3	3
CO5	2	2	2	2	1	-	-	-	-	-	-	1	2	2	3

Contents:

Characteristics of passive components for RF circuits. Passive RLC networks. Transmission lines. Two-port network modeling. S-parameter model. The Smith Chart and its applications.

Active devices for RF circuits: SiGe MOSFET, GaAs pHEMT, HBT and MESFET. PIN diode. Device parameters and their impact on circuit performance.

RF Amplifier design: single and multi-stage amplifiers. Review of analog filter design. Low-pass, high-pass, band-pass and band-reject filters. Bandwidth estimation methods. Voltage references and biasing.

Low Noise Amplifier design: noise types and their characterization, LNA topologies, power match vs noise match. Linearity and large-signal performance.

RF Power amplifiers: General properties. Class A, AB and C PAs. Class D, E and F amplifiers. Modulation of power amplifiers. Analog communication circuits: Mixers, phase-locked loops, oscillators and synthesizers. Design and performance characterization. Transceiver design. A/D and D/A convertors for RF applications.

Text Books

1. The Design of CMOS Radio Frequency Integrated Circuits, Lee Thomas H, Cambridge University Press.
2. Design of Analog CMOS integrated circuits, Razavi Behzad, McGraw Hill
3. VLSI for wireless communication Bosco Leung, Pearson Education
4. Ludwig and Bogdanov, RF Circuit Design Theory And Application.

ECP409 Radio Frequency Circuit Design [(0-0-2); Credit: 1]

Course Outcomes

Students will

1. be able to analyze an impedance transformation network using a software tool and use the circuit in their design.
2. be able to design physical lay-out of a passive component and evaluate its performance with software tools such as ADS or Microwave Office.
3. will be able to characterize an RF component or circuit using S-parameter matrix
4. be able to design RF amplifier and related circuits and evaluate the performance using software tools.
5. Be able to design mixers and oscillators and evaluate performance using software tools

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	2	3	-	-	-	2	2	-	1	2	2	1
CO2	2	2	3	2	3	-	-	-	2	2	-	1	2	2	3
CO3	2	2	2	2	3	-	-	-	2	2	-	1	1	2	3
CO4	2	2	3	2	3	-	-	-	2	2	-	1	2	3	3
CO5	2	2	3	2	3	-	-	-	2	2	-	1	2	3	3

Contents:

Phase-I: Simulation of impedance transformation passive networks

1. L- section upward transformation
2. L-section, downward transformation
3. π- circuit
4. T-circuit
5. Tapped capacitor resonator
6. Tapped inductor resonator
7. Double tapped resonator

For every network, plot the Z_{in} as function of frequency and load resistance R_s.

Phase-II: Simulation of passive RF components.

(Layout design and simulation, circuit models and parameter extraction, circuit simulation)

1. Design of resistor using poly-silicon over field oxide.
2. Parallel plate capacitor using poly-insulator-poly and metal-insulator-metal layers.
3. Lateral flux capacitors (inter-digitated, simple fractal)
4. Spiral inductor and transformer. (Use of Razavi's formula and Lee's formula)
5. Active resistor and MOS capacitor using MOSFETs

Phase-III: S parameter characterization of passive and active components

Using the advanced micro-strip trainer, find the S-parameters of the following components

1. Patch antenna (transformer feed and inset feed)
2. Low-pass filter
3. Band-pass filter
4. Band-reject filter
5. Ring resonator
6. Power divider (with and without isolation resistor)
7. Rat race hybrid ring coupler
8. Parallel line coupler
9. Branched line coupler
10. Amplifier

Phase-IV Design and simulation of active circuits

1. Common Source and Common Gate CMOS amplifier
2. Differential amplifier
3. Single ended LNA
4. Double ended LNA
5. Power amplifiers class A, B, C
6. Power amplifiers class D, E and F
7. Gilbert mixer
8. Colpitt and Hartley oscillators
9. Negative frequency oscillators

ECL417 Multimedia Networks [(3-0-0); Credits: 3]

***Pre-requisite: ECL303**

Course Outcomes

Students will

1. Understand functioning of circuit switched and packet switched networks
2. Be familiar with reasons for emergence of converged communication networks
3. Applications of various media coding algorithms
4. Be conversant with transport and signaling protocols
5. To learn with emerging trends in multimedia networks.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	-	2	0	1
CO2	3	-	-	-	-	-	-	-	-	-	-	1	2	0	1
CO3	3	-	-	-	-	-	-	-	-	-	-	1	2	0	1
CO4	3	-	-	-	3	-	-	-	-	-	-	1	2	0	1
CO5	3	-	-	-	3	-	-	-	-	-	-	2	2	0	1

Contents:

Review of circuit switched digital telephony, signaling and transmission, ISDN, SS7. Evolution of packet switched networks, Internet and LANs. The TCP/IP protocol stack.

Introduction to XoIP, network convergence, Needs of individual users, enterprises and network operators. How XoIP is expected to meet all these concerns. Source coding (speech, audio and video coding) PCM, ADPCM, LP coding, CELP, RPE-LTP, adaptive sub-band coding, MPEG standards for audio and video coding. Signaling protocols: Review of H.323, MEGACO protocols, Session Initiation Protocol (SIP), detailed study of SIP, implementation of SIP through Java. Media Transport: Need of special media transport protocols, RTP, RTCP, RTSP, QoS issues, routing, security etc.

Modern network technologies: mobile communication 3G, 4G, IMS, wireless LANs, wired networks. New services like IP-TV, multimedia conference calls, presence management, device and access independent services. VXML based applications

Books

1. O. Hersent, D. Gurle and JP Petit- “IP Telephony”, Pearson Education Asia
2. J. D. Gibson (Editor) “Multimedia Communications” – Harcourt India
3. Bill Douskalis “IP Telephony”, Prentice Hall
4. R. Wittman, M.Zitterbart-Morgan Kaufman, “Multicast Communication”.

ECL418 Network Planning and Management [(3-0-0); Credits: 3]

Course outcomes

Students will be able to

1. do traffic analysis for network planning
2. describe various procurement and installation procedures.
3. describe operation and maintenance systems for telecom networks
4. design an enterprise network based on the requirements of an organisation.
5. select appropriate protocols and applications for enterprise network management and diagnosis

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	3	3	2	2	-	-	-		-	2	2	3	3
CO2	1	2	2	1	1	2	-	-	-	1	2	2	3	2	2
CO3	1	2	2	1	1	2	-	-	-	1	2	2	3	2	2
CO4	2	2	3	2	2	2	-	-	-	1	3	2	2	2	2
CO5	2	2	2	2	2	1	-	-	-		1	1	2	2	3

Contents:

Network traffic data analysis and forecasting, resource planning, procurement and installation

Telecom network operation and maintenance system. Case studies of telecom, XoIP, MPLS, GSM, CDMA, LTE, VoLTE networks.

Enterprise need analysis and LAN design, component selection, procurement and installation.

Network management issues such as configuration management, fault and maintenance management, security and access management.

Management protocols such as SNMP, web based management tools such as Netconf, management protocol issues such as scalability, efficiency, effectiveness etc.

Books

1. Subramanian ; “Network Management” ; Addison Wesley (Low Price Edition)
2. McCabe J.D., “Network analysis, architecture and design”, Elsevier
3. FitzGerald J., Dennis A., “Business Data Communications and networking”.

ECL419 Wireless Sensor Networks [(3-0-2); Credits: 4]

***Pre-requisite: ECL429**

Course Outcomes

1. This course provides an introduction to fundamentals of wireless sensors.
2. Students will know about software platforms required for WSN.
3. Students can know about various MAC protocols for different communication standards used in WSN.
4. Students can explore new protocols for WSN.
5. Students will know about data gathering, data fusion etc. techniques.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	-	-	-	1	-	-	-	-	-	1	2	3	2
CO2	2	-	-	-	2	-	-	-	-	-	-	1	1	1	-
CO3	2	1	-	2	-	-	-	-	-	-	-	1	1	-	-
CO4	1	-	2	1	-	-	1	-	-	1	-	-	1	1	1
CO5	1	-	1	2	-	-	-	-	-	-	-	1	1	-	-

Contents:

Introduction to Sensor Networks, unique constraints and challenges, Advantage of Sensor Networks, Applications of Sensor Networks, Types of wireless sensor networks (underground, underwater)

Mobile Adhoc NETworks (MANETs) and Wireless Sensor Networks, Enabling technologies for Wireless Sensor Networks. Issues and challenges in wireless sensor networks

Routing protocols, MAC protocols: Classification of MAC Protocols, S-MAC Protocol, B-MAC protocol, IEEE 802.15.4 standard and ZigBee,

Dissemination protocol for large sensor network. Data dissemination, data gathering, and data fusion; Quality of a sensor network; Real-time traffic support and security protocols.

Design Principles for WSNs, Gateway Concepts, Need for gateway, WSN to Internet Communication, and Internet to WSN Communication.

Single-node architecture, Hardware components & design constraints,

Operating systems: introduction to TinyOS and nesC.

List of experiments:

1. Introduction to various sensor networks simulators
2. Compiling and building an application onto a mote
3. Experiments Using XCTU tool
4. Experiments based on different routing protocols using Netsim
5. Experiments on sensor boards such as advanced technology sensor board, crossbow etc.
6. Configuring gateway devices

Text Books

1 Waltenegus Dargie , Christian Poellabauer, Fundamentals Of Wireless Sensor Networks Theory And Practice By John Wiley & Sons Publications

Reference Books

1. Sabrie Soloman, SENSORS HANDBOOK by Mc Graw Hill publication.
2. Feng Zhao, Leonidas Guibas, Wireless Sensor Networks, Elsevier Publications.
3. Kazem Sohrby, Daniel Minoli, Wireless Sensor Networks: Technology, Protocols and Applications, Wiley-Inderscience
4. Philip Levis, And David Gay Tinyos Programming by Cambridge University Press.

ECL427 Broadband Communication [(3-0-0); Credits: 3]

***Pre-requisite: ECL303**

Course Outcomes

Students will

1. describe broadband network architectures, protocols, and technologies including ISDN, SONET, and ATM.
2. explain multiple access techniques and synchronization methods used in broadband systems.
3. analyze the structure and function of access networks like Cable Modems, PONs, and VSATs.
4. evaluate modern broadband wireless systems including OFDM, OFDMA, WiMAX, LTE, and 5G NR.
5. explore the role of specialized networks such as CATV, UWB, VPNs, and their integration with the Internet.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	1	2	1	0
CO2	1	3	1	-	-	-	-	-	-	-	-	1	1	1	2
CO3	1	2	2	-	-	-	1	-	-	-	-	1	1	1	1
CO4	2	2	1	-	-	-	1	-	-	-	-	1	2	2	1
CO5	2	2	1	-	-	-	1	-	-	2	-	1	2	3	2

Contents:

Introduction, Internet-based Networks, Networking Technologies, Multiple Access Techniques, Timing Synchronization, Delay Lock Loop, ISDN Physical Layer, ISDN Data Link Layer, Signaling System Number 7, BISDN and SONET, ATM Switch and Protocols, UWB, specialized video (DBS) and wireless networks; CATV architecture; and the role of the Internet in the broadband environment, Access Networks, Cable Modem Systems, PONs, Personal Communication Systems, VPNs, VSATs, CLOS Network Switch, OFDM Concept, OFDMA System, Multi-Carrier CDMA, WiMAX, 4G LTE and 5G NR access

Books

1. Introduction to Broadband Communication Systems, Cajetan M. Akujuobi, Matthew N.O. Sadiku, Scitech Publishing Inc, CRC Press, 2007.
2. Balaji Kumar, Broadband Communications, McGraw-Hill, 1998.
3. Robert Newman, Broadband Communications, Prentice Hall, 2002

ECL532 Wavelets and Multi-media Applications [(3-0-2); Credit: 4]

***Pre-requisites:** ECL-304 (Digital Signal Processing)

Course Outcomes:

1. Study the need for multi-resolution analysis.
2. Analyze the decomposition and reconstruction of signals.
3. Apply sub-spaces, wavelets, and their realization using filter banks.
4. Use wavelets in multimedia applications.
5. Design multimedia solutions using wavelets.

CO-PO Mapping (UG):

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	-	1	-	-	-	-	-	-	-	-	2	-	-
CO2	3	3	1	3	-	-	-	-	-	-	-	-	2	-	-
CO3	3	3	1	3	-	-	-	-	-	-	-	-	2	1	2
CO4	3	3	2	3	2	-	-	-	-	-	-	-	3	1	3
CO5	1	2	-	2	-	-	-	-	-	-	-	-	1	-	-

Contents:

Background: Limitations of Fourier, Time-Frequency Analysis, STFT, Need of multiresolution analysis/synthesis, time-frequency uncertainty principle, Concept of Ladder of Spaces and subspaces.

Continuous Wavelet Transform: Multiresolution analysis, basis functions, time and frequency resolutions, wavelet synthesis.

Discrete Wavelets and Filter banks: 1-D and 2-D wavelets, construction, properties, decomposition, reconstruction, multi-resolution and analysis, Wavelet Packets.

Multimedia Applications:

- Signal, Image and Video Compression Standards: JPEG, Sub-band decomposition JPEG 2000, DjVu and ECW for still images, JPEG XS, CineForm, and the BBC's Dirac
- Multimedia Signal Processing: Signal enhancement, Denoising
- Multimedia Security: Watermarking and Steganography

Beyond Wavelets: Non-orthogonal wavelets, non-separable, curvelets, contourlets, dual-tree DWT, etc.

Topics for Experiments:

Sr. No.	Topic	Experiment
1	Fourier Transform	● Implementation of Fourier Transform ● Limitations concerning non-stationary signal
2	Short Term Fourier Transform (STFT)	● Implementation of STFT ● Analysis of different window sizes ● Time-frequency resolution of STFT ● Application of STFT
3	Continuous Wavelet Transform	● Compute continuous wavelet transform ● Visualize continuous wavelet transform
4	Multiresolution Analysis	● Implement multiresolution analysis ● Signal analysis at different scales
5	Discrete Wavelet Transform (DWT)	● Implement 1D DWT ● Signal decomposition and reconstruction

6	2D Discrete Wavelet Transform	● Implement 2D DWT ● 2D Signal decomposition and reconstruction
7	Wavelet Packet	● Implement wavelet packet ● Analyse its efficiency for signal processing
8	DWT Applications	● Signal Compression ● Image Compression and Sub-band Decomposition ● Signal Enhancement and Denoising ● Multimedia Security - Watermarking

Textbooks:

1) N.G. Soman, K.P. Ramachandran, K.I. Resmi, “Insight into Wavelets: From Theory to Practice”, Third edition, PHI Learning Pvt. Ltd., 2010.
2) Chun-Shien Lu, Multimedia Security: Steganography and Digital Watermarking Techniques for Protection of Intellectual Property, Idea Group Publishing, ISBN: 1591401925

Reference books:

1) Ruye Wang, Introduction to Orthogonal Transforms: With Applications in Data Processing and Analysis, Cambridge University Press, ISN: 0521516889
2) Frank Y. Shih, Digital Watermarking and Steganography: Fundamentals and Techniques, CRC Press; 2nd edition, ISBN: 0367656434

ECL 4XX: Multivariate Statistical Analysis [(3-0-0); Credits: 3]

Prerequisite: MAL204: Probability Theory and Numerical Methods

Course outcomes: After completion of this course, students will

1. understand the notion of randomness in data and its quantitative descriptions.
2. analyse descriptive statistics and hypothesis testing through statistical methods.
3. analyse statistical intervals, point estimates and statistical inference from sample.
4. study single factor and multifactor analysis of variance.
5. develop and test multivariate regression models and performance.

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	-	-	-	-	-	-	-	1	1	1	1
CO2	3	3	1	1	-	-	-	-	-	-	-	1	1	2	1
CO3	3	3	1	1	-	-	-	-	-	-	-	1	1	2	1
CO4	3	3	1	1	-	1	-	-	-	-	-	1	1	2	1
CO5	3	2	1	1	-	-	-	-	-	-	-	1	1	1	1

Course Content:

Sampling, descriptive statistics, outlier detection, measures of central tendency, central limit theorem, point estimation of parameters, statistical intervals, common assumptions. Hypothesis Testing: Tests on mean of normal distribution with and without known variance, Hypothesis tests on variance and standard deviation, Inference on difference in means for comparative analysis of population, Inference on the variances of two populations. Empirical models, simple linear regression, properties of least square estimators, hypothesis tests in simple linear regression, confidence interval, adequacy of the regression model, Multiple linear regression model, hypothesis tests in multiple linear regression, confidence interval in multiple linear regression, Model adequacy checking

Books:

1. “Applied statistics and probability for engineers”,Montgomery, Douglas C., and George C. Runger, John Wiley & Sons, 2010.
2. "Discovering statistics using SPSS”, P. Field Andy, 2009.
3. “Applied probability and statistics”, Lefebvre, Mario, Springer Science & Business Media, 2007.
4. “Statistical inference”, Casella, George, and Roger L. Berger. Vol. 2. Pacific Grove, CA: Duxbury, 2002.

ECL4XX Embedded Systems for IoT [3-0-2; Credits: 4]

Course outcomes:

Students will be able to,

1. Define and explain various fundamentals of Internet of Things
2. Learn various fundamentals of embedded C and Micropython programming
3. Examine the evolution of embedded systems, interfacing
4. Differentiate and practice various wireless and low-energy protocols
5. Create interface and develop application programming interface for cloud connectivity

CO-PO mapping:

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	-	-	-	-	-	-	-	-	-	1	-	1	-
CO2	2	2	1	-	-	-	-	-	-	-	-	1	1	2	1
CO3	3	2	2	-	-	-	-	-	-	-	-	1	2	3	2
CO4	3	-	-	-	1	-	-	-	-	-	-	1	2	3	3
CO5	3	-	-	-	1	-	-	-	-	-	-	2	1	-	-

Course Content:

Getting Started: Introduction of IoT boards and platforms, Installing IoT integrated development environment. Overview, essentials, and GPIO configurations of IoT platforms.

Fundamentals of Programming using C, Micropython: Hands-on IDE, exploring the IoT board GPIOs: Digital Inputs and Outputs, Touch Sensor, Pulse-Width Modulation (PWM), Reading Analog Inputs. Concepts of serial communication, monitoring, plotting, and debugging.

Sensor Operation and Interfacing: Interfacing of various sensors like Hall Effect Sensor, Motion Sensor, pressure, temperature, humidity sensor, etc. used in various engineering applications.

Interrupts and Timers, Flash Memory: Store Permanent Data (Write and Read), Deep Sleep Mode: Timer, Touch, External Wake Up.

Web Servers: Control Outputs: HTML and CSS Basics, Password Protection, Display Sensor Readings, Remote controlling of devices.

BLE and Wi-Fi: Bluetooth Low Energy: Introduction, Notify and Scan, Server and Client. Wi-Fi: Access Point, Station modes.

Cloud-based IoT platform: Integration of IoT boards with cloud services and their operations.

Design and Applications of IoT systems: Design of various industrial, home, medical, agricultural, smart city, automation, wearable, consumer, transportation applications of IoT.

List of experiments to be implemented in embedded C/ Micro Python language (ESP-32 IOT based):

1. Accessing Touch and Temperature Sensor. [CO-2]
2. Establishing a Bluetooth Connection and Control Peripherals. [CO-3]
3. Establishing a Wi-Fi Connection and Control Peripherals. [CO-3]
4. Design A Telegram-Based Chatbot For Automation. [CO-4]
5. Demonstrate Google-Based Voice Assistant For Automation. [CO-4]
6. Demonstrate Parallel Tasks Using RTOS. [CO-4]
7. Demonstrate Task Suspension And Resuming Using RTOS. [CO-4]
8. A Mini Project Based On ESP-32. [CO-5]

Books:

1. “Learn ESP32 with Arduino IDE”, Rui Santos, (2nd Edition)
2. “Getting Started with Python for the Internet of Things”, Tim Cox Packt.

ECL 4xx Emerging Communication Technologies (3-0-2)

Course Outcomes:

After completing this course, the student will demonstrate the knowledge and ability to:

1. Understand the key concepts and architectures of emerging telecommunication technologies.
2. Explore the applications and implications of these technologies in real-world scenarios.
3. Develop skills to design, implement, and manage advanced telecommunication systems using MATLAB/Python, enhancing technical proficiency and problem-solving capabilities.
4. Analyze future trends and the evolution of telecommunication networks.
5. Learn to identify, address, and mitigate security challenges in modern communication networks

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	-	-	-	-	-	-	-	2	3	2	1
CO2	3	2	3	2	2	2	2	-	-	-	-	3	2	2	3
CO3	3	3	3	1	3	-	-	-	2	-	2	2	1	2	2
CO4	3	3	2	3	-	2	-	-	-	2	1	2	3	3	2
CO5	3	2	3	2	2	-	-	2	2	-	-	2	2	2	2

Contents:

Module 1: 5G and beyond

The 5G Use Cases, 5G Standards, Specification of 5G in 3GPP and NR, 5G architecture and key technologies (e.g., Massive MIMO, mmWave), Network slicing and its applications, Future trends: 6G vision (IRS, ISAC, FDC) and research directions.

Module 2: Internet of Things (IoT) Technologies and Applications

IoT protocols (e.g., MQTT, CoAP, LPWAN), communication models, and applications in various sectors like smart cities, healthcare, and industrial automation. Security and privacy in IoT networks.

Module 3: Software-Defined Networking (SDN) and Network Function Virtualization (NFV)

Concepts of SDN and NFV, their roles in modern communication networks, and implementation techniques. Use cases and benefits of SDN and NFV in industry.

Module 4: Edge Computing and Blockchain in Telecommunication

Edge computing principles, architectures, edge AI, latency and bandwidth optimization, and integration with 5G networks. Blockchain fundamentals, consensus algorithms, decentralized communication protocols, blockchain security, and use cases in communication systems.

Module 5: Future Trends

Discussion on current and future research directions in the field of modern communication.

Lab Experiment Topics:

1. Simulation of 5G Networks
2. System Modelling for mmWave communication with massive MIMO
3. RIS enabled ISAC Network
4. IoT Communication Protocol Implementation
5. SDN Controller Design and Implementation
6. NFV Service Chain Deployment
7. Edge Computing Simulation
8. Blockchain-Based Communication Protocol Implementation

Text Books:

1. Erik Dahlman, Stefan Parkvall, and Johan Sköld (2018), “5G NR: The Next Generation Wireless Access Technology”. Academic Press.
2. Arshdeep Bahga and Vijay Madisetti (2014). “Internet of Things: A hands-on approach”. Universities Press (India).

Reference Books:

1. William Stallings (2021), “5G Wireless: A Comprehensive Introduction”, Addison-Wesley Professional.
2. Oswald Coker (2017), “Software-Defined Networking with OpenFlow”. Packt Publishing.
3. Daniel Drescher (2017), “Blockchain Basics: A Non-Technical Introduction in 25 Steps”. APress

ECL5XX Microwave Integrated Circuits and Systems [(3-0-2); Credit: 4]

***Pre-requisites: ECL305** Electromagnetic Fields

Course Outcomes:

The students will be able to:

1. Describe the working principles and design aspects of MIC components' applications in microwave systems.
2. Analyse the complexities involved in microwave amplifier design and the principles behind microwave oscillators, including their stability features.
3. Apply knowledge of MIC filter design to create and implement different types of filters, understanding their specific applications and functionalities in microwave circuits.
4. Evaluate the stability features of various MIC filters and oscillators, by designing and implementing different types of MIC filters and oscillators.
5. Design and layout complete MIC systems.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	-	2	-	-	-	-	-	-	-	-	2	-	-
CO2	2	2	1	2	3	-	-	-	-	-	-	1	3	-	-
CO3	2	2	2	1	3	-	-	-	-	-	-	-	2	-	-
CO4	3	3	2	3	3	-	-	-	-	-	-	-	2	3	-
CO5	3	3	3	3	3	-	-	-	-	-	-	1	1	3	3

Course Contents

Review of Transmission Line Concepts: Two-port networks, ABCD and S-parameters, and their conversions.
Smith chart and its applications, impedance matching using lumped and distributed approaches. Open and Short-Circuited Lossless Transmission Lines

Microwave Passive Circuit Design: Characteristics, properties, design parameters, and applications.

Design and realization of MIC power dividers, equal Power, unequal, and Broadband power dividers. Coupled Line Directional Couplers, branch line couplers, rat race couplers and applications, and hybrid rings.

Microwave Filter Design: Filter design by insertion loss method, Richards and Kuroda transformations, Kinverters, and J-inverters. Resonator filters, realization using microstrip lines and strip lines. Transformation from LPF to other Filters, coupled Line filters.

Design of Microwave Amplifiers and Oscillators: Basics and Power Gain Expressions, Stability and Constant Gain Circles, Noise Sources and Noise Figure, Low Noise Amplifiers NF Circles and LNA Design, microwave mixers, and oscillators. Fixed and Variable Attenuators, RF switches, and phase shifters. MIC system design, Monolithic Microwave Integrated Circuits (MMIC).

Introduction to Millimetre wave and THz Technologies, and design challenges.

List of Experiments:

1. To design and simulate microstrip transmission lines and analyze their characteristics.
2. To measure the S-parameters of various microwave components such as filters, amplifiers, and couplers.

3. To design, simulate, and fabricate microstrip low-pass, high-pass, band-pass, and band-stop filters.
4. To design and analyze power dividers and directional couplers using microstrip technology.
5. To design and simulate a low-noise amplifier (LNA) and a power amplifier.
6. To design and implement impedance matching networks using the Smith chart. Tools: Smith chart tools, impedance matching software.
7. To design and analyze a microwave oscillator circuit.
8. To design, simulate, and implement, Microstrip Antenna, RF switches and phase shifters.
9. To design and test microwave mixers.
10. To fabricate and test various MIC components such as filters, couplers, and amplifiers.
11. To measure the effectiveness of different shielding techniques on microwave circuits.

Books and references

1. Pozar, D. M. Microwave Engineering. John Wiley & Sons, 2011.
2. Ludwig, R. RF Circuit Design: Theory & Applications, 2nd ed. Pearson Education India, 2000.
3. Misra, D. K. Radio-Frequency and Microwave Communication Circuits: Analysis and Design. John Wiley & Sons, 2012.

Tools/Software/Equipment Required:

1. Microwave simulation software (e.g., ADS, HFSS and CST).
2. Vector network analyzer (VNA) and Spectrum analyzer.
3. PCB fabrication tools and PCB Prototyping Machine
4. EMC design software, and EMI/EMC test equipment
5. Shielding materials
6. Anechoic Chamber

ECL4XX Medical Image Analysis (3-0-0)

Course Outcomes:

Upon successful completion of this course, students should be able to:

1. describe the principles and applications of different medical imaging modalities, including X-ray, CT, MRI, ultrasound, and PET.
2. apply the basic image processing techniques to medical imaging.
3. demonstrate the current and future roles of registration, fusion, and other techniques in high-level analysis and their potential benefits and disadvantages in application to clinical diagnosis.
4. critically evaluate current research literature in medical image analysis and solve complex problems related to medical imaging.
5. design and implement algorithm(s) for a medical image processing application.

UG

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

Course Content:

Medical Imaging Modalities, Anatomical and Functional imaging: X-ray, Computed tomography (CT), Magnetic resonance imaging (MRI), Nuclear imaging, Positron emission tomography (PET) Single photon emission computer tomography (SPECT), microscope images and their simple manipulation

Introduction to basic processing and quantification, Image visualization, Databases and challenges

Neural network for medical imaging and new evolutionary techniques

Medical image segmentation and Hands-on sessions, Multimodal medical image registration and fusion, Case studies

Medical Image classification/categorization, Computer aided radiology and diagnosis, Transferred learning, and deep features for medical image analysis

Advancement in deep learning algorithms applied for medical image analysis

Case studies on some recent advances in the analysis of retinal, CT, MRI, ultrasound, and histology images

Books:

1. Dhawan, A.P., Medical image analysis, CRC Press, 2010.

2. S.K. Zhout et al, Deep Learning for Medical Image Analysis, 2017.

3. W. Birkfellner. Applied Medical Image Processing. CRC Press, Taylor and Francis, 2010

4. I. Bankman, Handbook of Medical Imaging: Processing and Analysis (Biomedical Engineering), Academic Press/

ECL 4XX Quantum Computing and Quantum Communication (3-0-0)
Course Outcomes:

Upon successful completion of this course, students should be able to:

1. Understand the need and evolution of quantum-based computing and communication.
2. Comprehend the basics of qubits, measurement and various operations.
3. Demonstrate and apply various tools required to analyze and design quantum computing
4. Critically analyze and evaluate the performance various Quantum computing and communication algorithms.
5. Design/Create different test scenarios and identify which technique will work better in
6. various scenarios.

CO-PO Mapping [UG]

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

Course Content:

Principles of quantum computing/communications: Quantum Bits, Dirac Notation, Single and Multiple Qubit Gates, No Cloning Theorem, Quantum Teleportation, Quantum Interference, quantum gates and quantum circuits, circuit optimization rules.

Various Postulates and operators: Quantum state, Quantum Evolution, Quantum Measurement, POVM Operators, Density Operators, Hamiltonian Simulation, Quantum Entanglement.

Quantum Fourier Transform and algorithms: QFT Implementation in Cirq, Quantum Phase Implementation, Quantum Phase Estimation in Cirq, Shor's Period Finding Algorithm and Factoring, DJ algorithm, Grover's algorithm, Simon's algorithm.

Quantum error correction, various noise models for quantum communications: Basic idea of an error model, Threshold theorem for quantum communication, Shor code, quantum cryptography, QKD and various other protocols.

Text books:

1. Elements of Quantum Computation and Quantum Communication by Anirban Pathak, CRC press, 1st Edition, 2013.

Reference Books:

1. Quantum Computing and Communications - An Engineering Approach by S Imre, Wiley, 1st edition, 2005.
2. Quantum Information, Computation and Communications by Jonathan A Jones, Cambridge University Press, 1st edition, 2012

ECL4XX Industry Internship VII Sem [0-0-6; Credit: 3]

ECL4XX Industry Internship VIII Sem [0-0-6; Credit: 3]

ECL4XX MOOC1 [3-0-0; Credit: 3]

ECL4XX MOOC2 [3-0-0; Credit: 3]

ECL4XX MOOC3 [3-0-0; Credit: 3]

ECL4XX Independent Studies [0-2-0; Credit: 2]

Title of Minor (as it will appear in the degree certificate of the student):

Internet of Things (IoT)

Sr. No.	Course Code	Course Name	Structure L-T-P-Cr	Semester (Even / Odd)	*Pre-requisite(s) and /or any other condition for registration		Page No.
					Course Code	Course Name	
1	ECL217	Concepts of Communication	3-0-2-4	3	None	None	107
2	ECL316	Communication Networks for IoT	3-0-2-4	4	ECL217	Concepts of Communication	108
3	ECL441	IoT Design	3-0-2-4	5	ECL217 ECL316	Concepts of Communication Communication Networks for IoT	109
4	ECD404	IoT based Mini Project	0-0-8-4	6	ECL217 ECL316 ECL441	Concepts of Communication Communication Networks for IoT IoT Design	109
		Total Credits	**16**				

Program Specific Outcomes (PSO):

- PSO 1: Apply learning from Core and Disciplinary/Interdisciplinary elective courses in Electronics & Communication Engineering to IoT applications.
- PSO 2: Explore various technologies like IoT, Networking, Cloud, and Analytics to provide integrated solutions to real-world problems.
- PSO 3: Implement innovative, and cost-effective processes for producing integrated solutions for existing and new applications related to the IoT.

ECL217 Concepts of Communication [3-0-2; Credits: 4]

***Pre-requisite: None**

Course outcomes:

Students will be able to

1. Define and explain various fundamentals of analog communication systems
2. Define and explain various fundamentals of digital communication systems
3. Examine the evolution of wireless and cellular systems
4. Describe the principles of optical communication
5. Describe the principles of Satellite communication

CO-PO mapping:

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	-	1	-	-	-	-	-	1	3	3	3
CO2	3	3	1	1	-	1	-	-	-	-	-	1	3	3	3
CO3	3	3	2	2	-	-	-	-	-	-	-	1	2	3	3
CO4	3	3	2	2	-	-	-	-	-	-	-	1	3	2	2
CO5	3	3	1	1	-	1	-	-	-	-	-	1	2	2	3

Contents:

Introduction to the communication system, Element of communication system, Types of signals, Time and Frequency domains, Noise and Communication, Spectral analysis.

Modulation Theory, Need and Types of modulation, Overview of AM and FM modulation systems. AM & FM transmitters and Receivers (Superheterodyne receiver), Concept of pulse communication PAM, PWM, PPM

Principles of Digital Communications, Merits and Demerits of Digital Communication over Analog Communications. Overview of PCM, DM, ADM, SDM ASK, FSK & PSK. Overview of various multiplexing techniques, FDM, TDM, CDMA, OFDM

Overview of wireless and Cellular communication, Generation of Mobile communications (4G, 5G, LTE) GSM and CDMA frequency bands, the concept of frequency reuse, and various types of handoffs.

Introduction to optical fiber communications, principles, types of fibers, WDM typical applications.

Introduction to Satellite communications: working principle, types, Frequency band of operations.

Principle of Radar Communication, Types and frequency band of Radar

Introduction to antennas, Types of antenna (monopole, dipole, Yagi Uda, patch, parabola horn), Concept of antenna array.

Text Books

1. Title: Electronic Communication Systems, Author: Roy Blake, Publisher: Cengage, Edition: Second
2. Title: Mobile Communications, Author: Joechen Schiller, Publisher: Pearson, Edition: Second

Reference Books

1. Title: Communication Electronics- Principle and Applications, Author: Frenzel Publisher: TMH, Edition: Third

ECL316 Communication Networks for IoT [3-0-2; Credits: 4]

***Pre-requisite: ECL217 Concepts of Communication**

Course outcomes:

Students will be able to,

1. Distinguish between various network topologies and types of switching
2. Examine various medium access protocols and network hardware components
3. Differentiate various types of networking devices
4. Know fundamental concepts of IP and routing protocols
5. Examine the building blocks of XoIP

CO-PO mapping:

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1	1	2	1	1	1	1	1	1	1	2	3	1
CO2	2	2	2	1	3	1	1	1	1	1	1	1	2	3	1
CO3	3	1	1	3	3	3	1	1	1	2	1	2	3	3	2
CO4	3	2	1	3	3	1	3	1	1	1	1	1	2	3	1
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3

Contents:

Basics of Network and its types: Topologies, Evolution of Networks and Ethernet, Introduction to packet-switched networks, Internet, and LANs. Servers, Clients, Ports and Protocols.

The TCP/IP, UDP model: Bits, Frames, Packets, Segments, HTTP captures, Port Numbers

Fundamentals of IP addressing: Characteristics and IPv4 Address Format, Classless/ Classful addressing, subnetting, CIDR notations

Networking Devices and data flow: Repeaters, Hubs, Switches and Routers, Firewalls, IDS, IPS and WLC,

IP Routing: Routing and Forwarding, General Routing Protocols, Routing for Adhoc Wireless Network, Static, Dynamic, DHCP

XoIP protocols: signaling protocols H.323 protocols, Session Initiation Protocol (SIP). Media Transport protocols, RTP, RTCP, RTSP, QoS.

IPv6: Addressing, Routing, Troubleshooting

Text Books:

1. Behrouz A. Forouzan, Data Communications and Networking, (5th Edition), McGraw Hill

ECL441 IoT Design [3-0-2; Credits: 4]

***Pre-requisite: ECL217: Concepts of Communication, ECL316: Communication Networks for IoT**

Course outcomes:

Students will be able to,

1. Define and explain various fundamentals of Internet of Things
2. Learn various fundamentals of embedded C programming
3. Examine the evolution of embedded systems, interfacing
4. Learn various wireless and low-energy protocols
5. Create interface and develop application programming interface for cloud connectivity.

CO-PO mapping:

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1	1	2-	1	1	1	1	1	1	1	2	3	1
CO2	2	2	2	1	3	1	1	1	1	1	1	1	2	3	1
CO3	3	1	1	3	3	3	1	1	1	2	1	2	3	3	2
CO4	3	2	1	3	3	1	3	1	1	1	1	1	2	3	1
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3

Contents:

Getting Started: Introduction of IoT boards and platforms, Installing IoT integrated development environment. Overview, essentials, and GPIO configurations of IoT platforms.
Fundamentals of Programming using C, Micropython: Hands-on IDE, exploring the IoT board GPIOs: Digital Inputs and Outputs, Touch Sensor, Pulse-Width Modulation (PWM), Reading Analog Inputs. Concepts of serial communication, monitoring, plotting, and debugging.
Sensor Operation and Interfacing: Interfacing of various sensors like Hall Effect Sensor, Motion Sensor, pressure, temperature, humidity sensor, etc. used in various engineering applications.
Interrupts and Timers, Flash Memory: Store Permanent Data (Write and Read), Deep Sleep Mode: Timer, Touch, External Wake Up.
Web Servers: Control Outputs: HTML and CSS Basics, Password Protection, Display Sensor Readings, Remote controlling of devices.
BLE and Wi-Fi: Bluetooth Low Energy: Introduction, Notify and Scan, Server and Client. Wi-Fi: Access Point, Station modes.
Cloud-based IoT platform: Integration of IoT boards with cloud services and their operations.
Design and Applications of IoT systems: Design of various industrial, home, medical, agricultural, smart city, automation, wearable, consumer, transportation applications of IoT.

Text Books:

1. Rui Santos, Learn ESP32 with Arduino IDE, (2nd Edition)
2. Tim Cox, Getting Started with Python for the Internet of Things, Packt

ECD4XX IoT based Mini Project [0-0-8; Credits: 4]

---------- End of Syllabus and Scheme.----------