VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF ELECTRONICS ENGINEERING

B. Tech Electronics and Communication Engineering

Curriculum

(***2021-22*** *admitted students*)

VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

World class Education: Excellence in education, grounded in ethics and critical thinking, for improvement of life.

Cutting edge Research: An innovation ecosystem to extend knowledge and solve critical problems.

Impactful People: Happy, accountable, caring and effective workforce and students.

Rewarding Co-creations: Active collaboration with national & international industries & universities for productivity and economic development.

Service to Society: Service to the region and world through knowledge and compassion.

VISION STATEMENT OF THE SCHOOL OF ELECTRONICS ENGINEERING

To be a leader by imparting in-depth knowledge in Electronics Engineering, nurturing engineers, technologists and researchers of highest competence, who would engage in sustainable development to cater the global needs of industry and society.

MISSION STATEMENT OF THE SCHOOL OF ELECTRONICS ENGINEERING

- Create and maintain an environment to excel in teaching, learning and applied research in the fields of electronics, communication engineering and allied disciplines which pioneer for sustainable growth.
- Equip our students with necessary knowledge and skills which enable them to be lifelong learners to solve practical problems and to improve the quality of human life.

B. Tech Electronics and Communication Engineering

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be engineering practitioners and leaders, who would help solve industry's technological problems

2. Graduates will be engineering professionals, innovators or entrepreneurs engaged in technology development, technology deployment, or engineering system implementation in industry

3. Graduates will function in their profession with social awareness and responsibility

4. Graduates will interact with their peers in other disciplines in industry and society and contribute to the economic growth of the country

5. Graduates will be successful in pursuing higher studies in engineering or management

6. Graduates will pursue career paths in teaching or research

B. Tech Electronics and Communication Engineering

PROGRAMME OUTCOMES (POs)

PO_01. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO_02. 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.

PO_03. 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.

PO_04. 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.

PO_05. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO_06. 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.

PO_07. 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.

PO_08. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO_09. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO_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.

PO_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.

PO_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.

B. Tech Electronics and Communication Engineering

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of B. Tech. (Electronics and Communication Engineering) Programme, graduates will be able to

PSO_01. Design and analyse the different electronic circuits and systems.

PSO_02. Design and develop the communication systems for various applications

PSO_03. Use modern tools and techniques to solve contemporary problems in the field of Electronics and Communication Engineering

CREDIT INFO		
S.no	**Catagory**	**Credit**
1	Foundation Core	51
2	Discipline-linked Engineering Sciences	10
3	Discipline Core	51
4	Discipline Elective	15
5	Projects and Internship	9
6	Open Elective	15
7	Bridge Course	0
8	Non-graded Core Requirement	11
Total Credits		162

Foundation Core									
sl.no	**Course Code**	**Course Title**	**Course Type**	**Version**	**L**	**T**	**P**	**J**	**Credit**
1	BCHY101L	Engineering Chemistry	Theory Only	1.0	3	0	0	0	3.0
2	BCHY101P	Engineering Chemistry Lab	Lab Only	1.0	0	0	2	0	1.0
3	BCSE101E	Computer Programming: Python	Embedded Theory and Lab	1.0	1	0	4	0	3.0
4	BCSE103E	Computer Programming: Java	Embedded Theory and Lab	1.0	1	0	4	0	3.0
5	BECE101L	Basic Electronics	Theory Only	1.0	2	0	0	0	2.0
6	BECE101P	Basic Electronics Lab	Lab Only	1.0	0	0	2	0	1.0
7	BEEE101L	Basic Electrical Engineering	Theory Only	1.0	2	0	0	0	2.0
8	BEEE101P	Basic Electrical Engineering Lab	Lab Only	1.0	0	0	2	0	1.0
9	BENG101L	Technical English Communication	Theory Only	1.0	2	0	0	0	2.0
10	BENG101P	Technical English Communication Lab	Lab Only	1.0	0	0	2	0	1.0
11	BENG102P	Technical Report Writing	Lab Only	1.0	0	0	2	0	1.0
12	BFLE200L	B.Tech. Foreign Language - 2021onwards	Basket	1.0	0	0	0	0	2.0
13	BHSM200L	B.Tech. HSM Elective - 2021 onwards	Basket	1.0	0	0	0	0	3.0
14	BMAT101L	Calculus	Theory Only	1.0	3	0	0	0	3.0
15	BMAT101P	Calculus Lab	Lab Only	1.0	0	0	2	0	1.0
16	BMAT102L	Differential Equations and Transforms	Theory Only	1.0	3	1	0	0	4.0
17	BMAT201L	Complex Variables and Linear Algebra	Theory Only	1.0	3	1	0	0	4.0
18	BMAT202L	Probability and Statistics	Theory Only	1.0	3	0	0	0	3.0
19	BMAT202P	Probability and Statistics Lab	Lab Only	1.0	0	0	2	0	1.0
20	BPHY101L	Engineering Physics	Theory Only	1.0	3	0	0	0	3.0
21	BPHY101P	Engineering Physics Lab	Lab Only	1.0	0	0	2	0	1.0
22	BSTS101P	Quantitative Skills Practice I	Soft Skill	1.0	0	0	3	0	1.5
23	BSTS102P	Quantitative Skills Practice II	Soft Skill	1.0	0	0	3	0	1.5
24	BSTS201P	Qualitative Skills Practice I	Soft Skill	1.0	0	0	3	0	1.5
25	BSTS202P	Qualitative Skills Practice II	Soft Skill	1.0	0	0	3	0	1.5

Discipline-linked Engineering Sciences									
sl.no	Course Code	Course Title	Course Type	Version	L	T	P	J	Credit
1	BECE201L	Electronic Materials and Devices	Theory Only	1.0	3	0	0	0	3.0
2	BECE202L	Signals and Systems	Theory Only	1.0	2	1	0	0	3.0
3	BECE203L	Circuit Theory	Theory Only	1.0	3	1	0	0	4.0

Discipline Core									
sl.no	Course Code	Course Title	Course Type	Version	L	T	P	J	Credit
1	BECE102L	Digital Systems Design	Theory Only	1.0	3	0	0	0	3.0
2	BECE102P	Digital Systems Design Lab	Lab Only	1.0	0	0	2	0	1.0
3	BECE204L	Microprocessors and Microcontrollers	Theory Only	1.0	3	0	0	0	3.0
4	BECE204P	Microprocessors and Microcontrollers Lab	Lab Only	1.0	0	0	2	0	1.0
5	BECE205L	Engineering Electromagnetics	Theory Only	1.0	3	0	0	0	3.0
6	BECE206L	Analog Circuits	Theory Only	1.0	3	0	0	0	3.0
7	BECE206P	Analog Circuits Lab	Lab Only	1.0	0	0	2	0	1.0
8	BECE207L	Random Processes	Theory Only	1.0	2	1	0	0	3.0
9	BECE301L	Digital Signal Processing	Theory Only	1.0	3	0	0	0	3.0
10	BECE301P	Digital Signal Processing Lab	Lab Only	1.0	0	0	2	0	1.0
11	BECE302L	Control Systems	Theory Only	1.0	2	1	0	0	3.0
12	BECE303L	VLSI System Design	Theory Only	1.0	3	0	0	0	3.0
13	BECE303P	VLSI System Design Lab	Lab Only	1.0	0	0	2	0	1.0
14	BECE304L	Analog Communication Systems	Theory Only	1.0	3	0	0	0	3.0
15	BECE304P	Analog Communication Systems Lab	Lab Only	1.0	0	0	2	0	1.0
16	BECE305L	Antenna and Microwave Engineering	Theory Only	1.0	3	0	0	0	3.0
17	BECE305P	Antenna and Microwave Engineering Lab	Lab Only	1.0	0	0	2	0	1.0
18	BECE306L	Digital Communication Systems	Theory Only	1.0	3	0	0	0	3.0
19	BECE306P	Digital Communication Systems Lab	Lab Only	1.0	0	0	2	0	1.0
20	BECE307L	Wireless and Mobile Communications	Theory Only	1.0	2	0	0	0	2.0
21	BECE307P	Wireless and Mobile Communications Lab	Lab Only	1.0	0	0	2	0	1.0
22	BECE308L	Optical Fiber Communications	Theory Only	1.0	2	0	0	0	2.0
23	BECE308P	Optical Fiber Communications Lab	Lab Only	1.0	0	0	2	0	1.0
24	BECE401L	Computer Communications and Networks	Theory Only	1.0	3	0	0	0	3.0
25	BECE401P	Computer Communications and Networks Lab	Lab Only	1.0	0	0	2	0	1.0

Discipline Elective									
sl.no	Course Code	Course Title	Course Type	Version	L	T	P	J	Credit
1	BECE208E	Data Structures and Algorithms	Embedded Theory and Lab	1.0	2	0	2	0	3.0

Discipline Elective									
2	BECE209E	Structured and Object Oriented Programming	Embedded Theory and Lab	1.0	2	0	4	0	4.0
3	BECE309L	Artificial Intelligence and Machine Learning	Theory Only	1.0	3	0	0	0	3.0
4	BECE310L	Satellite Communications	Theory Only	1.0	3	0	0	0	3.0
5	BECE311L	Radar Systems	Theory Only	1.0	3	0	0	0	3.0
6	BECE312L	Robotics and Automation	Theory Only	1.0	3	0	0	0	3.0
7	BECE313L	Information Theory and Coding	Theory Only	1.0	3	0	0	0	3.0
8	BECE314L	Electromagnetic Interference and Compatibility	Theory Only	1.0	2	1	0	0	3.0
9	BECE315L	Optical Networks	Theory Only	1.0	3	0	0	0	3.0
10	BECE316E	Digital Image Processing	Embedded Theory and Lab	1.0	3	0	2	0	4.0
11	BECE320E	Embedded C Programming	Embedded Theory and Lab	1.0	2	0	2	0	3.0
12	BECE391J	Technical Answers to Real Problems Project	Project	1.0	0	0	0	0	3.0
13	BECE392J	Design Project	Project	1.0	0	0	0	0	3.0
14	BECE393J	Laboratory Project	Project	1.0	0	0	0	0	3.0
15	BECE394J	Product Development Project	Project	1.0	0	0	0	0	3.0
16	BECE396J	Reading Course	Project	1.0	0	0	0	0	3.0
17	BECE397J	Special Project	Project	1.0	0	0	0	0	3.0
18	BECE398J	Simulation Project	Project	1.0	0	0	0	0	3.0
19	BECE403E	Embedded Systems Design	Embedded Theory and Lab	1.0	3	0	2	0	4.0
20	BECE404L	Detection, Estimation and Modulation Theory	Theory Only	1.0	3	0	0	0	3.0
21	BECE405L	Cognitive Radio Networks	Theory Only	1.0	3	0	0	0	3.0
22	BECE406E	FPGA Based System Design	Embedded Theory and Lab	1.0	2	0	2	0	3.0
23	BECE407E	ASIC Design	Embedded Theory and Lab	1.0	2	0	2	0	3.0
24	BECE408L	Micorwave Integrated Circuits	Theory Only	1.0	3	0	0	0	3.0
25	BECE409E	Sensors Technology	Embedded Theory and Lab	1.0	2	0	2	0	3.0
26	BECE410L	Micro-Electromechanical Systems	Theory Only	1.0	3	0	0	0	3.0
27	BECE411L	Cryptography and Network Security	Theory Only	1.0	3	0	0	0	3.0

Projects and Internship									
sl.no	**Course Code**	**Course Title**	**Course Type**	**Version**	**L**	**T**	**P**	**J**	**Credit**
1	BECE399J	Summer Industrial Internship	Project	1.0	0	0	0	0	1.0
2	BECE497J	Project - I	Project	1.0	0	0	0	0	3.0
3	BECE498J	Project - II / Internship	Project	1.0	0	0	0	0	5.0
4	BECE499J	One Semester Internship	Project	1.0	0	0	0	0	14.0

Open Elective									
sl.no	Course Code	Course Title	Course Type	Version	L	T	P	J	Credit
1	BECE351E	Internet of Things	Embedded Theory and Lab	1.0	1	0	2	0	2.0
2	BECE352E	IoT Domain Analyst	Embedded Theory and Lab	1.0	1	0	2	0	2.0
3	BEEE202L	Electromagnetic Theory	Theory Only	1.0	2	1	0	0	3.0
4	BHUM201L	Mass Communication	Theory Only	1.0	3	0	0	0	3.0
5	BHUM202L	Rural Development	Theory Only	1.0	3	0	0	0	3.0
6	BHUM203L	Introduction to Psychology	Theory Only	1.0	3	0	0	0	3.0
7	BHUM204L	Industrial Psychology	Theory Only	1.0	3	0	0	0	3.0
8	BHUM205L	Development Economics	Theory Only	1.0	3	0	0	0	3.0
9	BHUM206L	International Economics	Theory Only	1.0	3	0	0	0	3.0
10	BHUM207L	Engineering Economics	Theory Only	1.0	3	0	0	0	3.0
11	BHUM208L	Economics of Strategy	Theory Only	1.0	3	0	0	0	3.0
12	BHUM209L	Game Theory	Theory Only	1.0	3	0	0	0	3.0
13	BHUM210E	Econometrics	Embedded Theory and Lab	1.0	2	0	2	0	3.0
14	BHUM211L	Behavioral Economics	Theory Only	1.0	3	0	0	0	3.0
15	BHUM212L	Mathematics for Economic Analysis	Theory Only	1.0	3	0	0	0	3.0
16	BHUM213L	Corporate Social Responsibility	Theory Only	1.0	3	0	0	0	3.0
17	BHUM214L	Political Science	Theory Only	1.0	3	0	0	0	3.0
18	BHUM215L	International Relations	Theory Only	1.0	3	0	0	0	3.0
19	BHUM216L	Indian Culture and Heritage	Theory Only	1.0	3	0	0	0	3.0
20	BHUM217L	Contemporary India	Theory Only	1.0	3	0	0	0	3.0
21	BHUM218L	Financial Management	Theory Only	1.0	3	0	0	0	3.0
22	BHUM219L	Principles of Accounting	Theory Only	1.0	3	0	0	0	3.0
23	BHUM220L	Financial Markets and Institutions	Theory Only	1.0	3	0	0	0	3.0
24	BHUM221L	Economics of Money, Banking and Financial Markets	Theory Only	1.0	3	0	0	0	3.0
25	BHUM222L	Security Analysis and Portfolio Management	Theory Only	1.0	3	0	0	0	3.0
26	BHUM223L	Options , Futures and other Derivatives	Theory Only	1.0	3	0	0	0	3.0
27	BHUM224L	Fixed Income Securities	Theory Only	1.0	3	0	0	0	3.0
28	BHUM225L	Personal Finance	Theory Only	1.0	3	0	0	0	3.0
29	BHUM226L	Corporate Finance	Theory Only	1.0	3	0	0	0	3.0
30	BHUM227L	Financial Statement Analysis	Theory Only	1.0	3	0	0	0	3.0
31	BHUM228L	Cost and Management Accounting	Theory Only	1.0	3	0	0	0	3.0
32	BHUM229L	Mind, Embodiment and Technology	Theory Only	1.0	3	0	0	0	3.0
33	BHUM230L	Health Humanities in Biotechnological Era	Theory Only	1.0	3	0	0	0	3.0
34	BMAT100L	Mathematics	Theory Only	1.0	3	1	0	0	4.0
35	BMEE102P	Engineering Design Visualisation Lab	Lab Only	1.0	0	0	4	0	2.0
36	BMEE201L	Engineering Mechanics	Theory Only	1.0	2	1	0	0	3.0
37	BSTS301P	Advanced Competitive Coding - I	Soft Skill	1.0	0	0	3	0	1.5
38	BSTS302P	Advanced Competitive Coding - II	Soft Skill	1.0	0	0	3	0	1.5

Open Elective									
39	CFOC102M	Introduction to Cognitive Psychology	Online Course	1.0	0	0	0	0	3.0
40	CFOC103M	Introduction to Political Theory	Online Course	1.0	0	0	0	0	3.0
41	CFOC104M	Six Sigma	Online Course	1.0	0	0	0	0	3.0
42	CFOC105M	Emotional Intelligence	Online Course	1.0	0	0	0	0	2.0
43	CFOC109M	Design Thinking - A Primer	Online Course	1.0	0	0	0	0	1.0
44	CFOC113M	Contemporary Themes in India’s Economic Development and Economic Survey	Online Course	1.0	0	0	0	0	3.0
45	CFOC115M	Design and Analysis of Algorithms	Online Course	1.0	0	0	0	0	2.0
46	CFOC116M	Computer Vision	Online Course	1.0	0	0	0	0	3.0
47	CFOC119M	Training of Trainers	Online Course	1.0	0	0	0	0	3.0
48	CFOC120M	Knowledge Management	Online Course	1.0	0	0	0	0	2.0
49	CFOC121M	Leadership	Online Course	1.0	0	0	0	0	1.0
50	CFOC122M	Educational Leadership	Online Course	1.0	0	0	0	0	2.0
51	CFOC123M	Cost Accounting	Online Course	1.0	0	0	0	0	1.0
52	CFOC126M	Data Analysis and Decision Making - III	Online Course	1.0	0	0	0	0	3.0
53	CFOC128M	Business Analytics and Text Mining Modeling Using Python	Online Course	1.0	0	0	0	0	2.0
54	CFOC130M	Human Resource Development	Online Course	1.0	0	0	0	0	3.0
55	CFOC133M	E-Business	Online Course	1.0	0	0	0	0	3.0
56	CFOC134M	Innovation, Business Models and Entrepreneurship	Online Course	1.0	0	0	0	0	2.0
57	CFOC136M	Toyota Production System	Online Course	1.0	0	0	0	0	2.0
58	CFOC148M	Introduction to Wireless and Cellular Communications	Online Course	1.0	0	0	0	0	3.0
59	CFOC150M	Microelectronics: Devices To Circuits	Online Course	1.0	0	0	0	0	3.0
60	CFOC151M	Digital Image Processing	Online Course	1.0	0	0	0	0	3.0
61	CFOC152M	Pattern Recognition and Application	Online Course	1.0	0	0	0	0	3.0
62	CFOC154M	Principles and Techniques of Modern Radar Systems	Online Course	1.0	0	0	0	0	3.0
63	CFOC158M	Reinforcement Learning	Online Course	1.0	0	0	0	0	3.0
64	CFOC159M	Applied Natural Language Processing	Online Course	1.0	0	0	0	0	3.0
65	CFOC160M	Python for Data Science	Online Course	1.0	0	0	0	0	1.0
66	CFOC161M	Data Science for Engineers	Online Course	1.0	0	0	0	0	2.0
67	CFOC165M	Software testing	Online Course	1.0	0	0	0	0	3.0
68	CFOC166M	Hardware Modeling using Verilog	Online Course	1.0	0	0	0	0	2.0
69	CFOC177M	Drug Delivery: Principles and Engineering	Online Course	1.0	0	0	0	0	3.0
70	CFOC178M	Functional Genomics	Online Course	1.0	0	0	0	0	1.0
71	CFOC181M	WildLife Conservation	Online Course	1.0	0	0	0	0	2.0
72	CFOC188M	Ethical Hacking	Online Course	1.0	0	0	0	0	3.0
73	CFOC189M	Organic Farming for Sustainable Agricultural Production	Online Course	1.0	0	0	0	0	2.0
74	CFOC191M	Forests and their Management	Online Course	1.0	0	0	0	0	3.0
75	CFOC203M	Natural Hazards	Online Course	1.0	0	0	0	0	2.0
76	CFOC221M	Cloud computing	Online Course	1.0	0	0	0	0	2.0
77	CFOC222M	Artificial Intelligence : Knowledge Representation And Reasoning	Online Course	1.0	0	0	0	0	3.0
78	CFOC223M	Privacy and Security in Online Social Media	Online Course	1.0	0	0	0	0	2.0

Open Elective									
79	CFOC227M	GPU Architectures and Programming	Online Course	1.0	0	0	0	0	3.0
80	CFOC228M	Multi-Core Computer Architecture - Storage and Interconnects	Online Course	1.0	0	0	0	0	2.0
81	CFOC229M	Data Analytics with Python	Online Course	1.0	0	0	0	0	3.0
82	CFOC231M	Google Cloud Computing Foundation Course	Online Course	1.0	0	0	0	0	2.0
83	CFOC233M	Enhancing Soft Skills and Personality	Online Course	1.0	0	0	0	0	2.0
84	CFOC234M	Introduction to Airplane Performance	Online Course	1.0	0	0	0	0	2.0
85	CFOC235M	Rocket Propulsion	Online Course	1.0	0	0	0	0	3.0
86	CFOC237M	Sustainable Architecture	Online Course	1.0	0	0	0	0	3.0
87	CFOC265M	Geomorphology	Online Course	1.0	0	0	0	0	3.0
88	CFOC277M	Process Control - Design, Analysis and Assessment	Online Course	1.0	0	0	0	0	3.0
89	CFOC282M	Waste to Energy Conversion	Online Course	1.0	0	0	0	0	2.0
90	CFOC290M	Operating System	Online Course	1.0	0	0	0	0	3.0
91	CFOC292M	Programming in Java	Online Course	1.0	0	0	0	0	3.0
92	CFOC293M	Data Base Management System	Online Course	1.0	0	0	0	0	2.0
93	CFOC294M	Introduction to Algorithms and Analysis	Online Course	1.0	0	0	0	0	3.0
94	CFOC300M	Introduction to Internet of Things	Online Course	1.0	0	0	0	0	3.0
95	CFOC301M	Computer Networks and Internet Protocol	Online Course	1.0	0	0	0	0	3.0
96	CFOC302M	Introduction to Industry 4.0 and Industrial Internet of Things	Online Course	1.0	0	0	0	0	3.0
97	CFOC306M	Social Networks	Online Course	1.0	0	0	0	0	3.0
98	CFOC308M	The Joy of Computing using Python	Online Course	1.0	0	0	0	0	3.0
99	CFOC309M	Discrete Mathematics	Online Course	1.0	0	0	0	0	3.0
100	CFOC310M	An Introduction to Artificial Intelligence	Online Course	1.0	0	0	0	0	3.0
101	CFOC311M	User-centric Computing for Human-Computer Interaction	Online Course	1.0	0	0	0	0	3.0
102	CFOC312M	Cloud Computing and Distributed Systems	Online Course	1.0	0	0	0	0	2.0
103	CFOC315M	An Introduction To Programming Through C++	Online Course	1.0	0	0	0	0	3.0
104	CFOC329M	Design, Technology and Innovation	Online Course	1.0	0	0	0	0	2.0
105	CFOC334M	High Power Multilevel Converters-Analysis, Design and Operational Issues	Online Course	1.0	0	0	0	0	3.0
106	CFOC344M	Electronic Systems for Cancer Diagnosis	Online Course	1.0	0	0	0	0	3.0
107	CFOC355M	Analog IC Design	Online Course	1.0	0	0	0	0	3.0
108	CFOC378M	Statistical Signal Processing	Online Course	1.0	0	0	0	0	3.0
109	CFOC388M	Energy Resources, Economics and Environment	Online Course	1.0	0	0	0	0	3.0
110	CFOC393M	Introduction to Cultural Studies	Online Course	1.0	0	0	0	0	3.0
111	CFOC394M	Introduction to Basic Spoken Sanskrit	Online Course	1.0	0	0	0	0	1.0
112	CFOC395M	Speaking Effectively	Online Course	1.0	0	0	0	0	2.0
113	CFOC396M	Soft Skill Development	Online Course	1.0	0	0	0	0	2.0
114	CFOC398M	English Language for Competitive Exams	Online Course	1.0	0	0	0	0	3.0
115	CFOC404M	Patent Law for Engineers and Scientists	Online Course	1.0	0	0	0	0	3.0
116	CFOC413M	Indian Business History	Online Course	1.0	0	0	0	0	2.0
117	CFOC416M	Feminism : Concepts and Theories	Online Course	1.0	0	0	0	0	3.0
118	CFOC447M	Power Plant Engineering	Online Course	1.0	0	0	0	0	2.0

Open Elective									
119	CFOC464M	Operations Management	Online Course	1.0	0	0	0	0	3.0
120	CFOC472M	Industrial Automation And Control	Online Course	1.0	0	0	0	0	3.0
121	CFOC485M	Services Marketing : Integrating People, Technology, Strategy	Online Course	1.0	0	0	0	0	2.0
122	CFOC488M	Business Analytics For Management Decision	Online Course	1.0	0	0	0	0	3.0
123	CFOC497M	Financial Statement Analysis and Reporting	Online Course	1.0	0	0	0	0	3.0
124	CFOC499M	Global Marketing Management	Online Course	1.0	0	0	0	0	2.0
125	CFOC503M	Marketing Analytics	Online Course	1.0	0	0	0	0	3.0
126	CFOC508M	Entrepreneurship	Online Course	1.0	0	0	0	0	3.0
127	CFOC526M	Quantum Mechanics I	Online Course	1.0	0	0	0	0	3.0

Bridge Course									
sl.no	**Course Code**	**Course Title**	**Course Type**	**Version**	**L**	**T**	**P**	**J**	**Credit**
1	BBIT100N	Biology	Theory Only	1.0	3	0	0	0	3.0
2	BENG101N	Effective English Communication	Lab Only	1.0	0	0	4	0	2.0

Non-graded Core Requirement									
sl.no	**Course Code**	**Course Title**	**Course Type**	**Version**	**L**	**T**	**P**	**J**	**Credit**
1	BCHY102N	Environmental Sciences	Online Course	1.0	0	0	0	0	2.0
2	BECE101N	Introduction to Engineering	Project	1.0	0	0	0	0	1.0
3	BEXC100N	Extracurricular Activities / Co-Curricular Activities - B.Tech. Programmes	Basket	1.0	0	0	0	0	2.0
4	BHUM101N	Ethics and Values	Online Course	1.0	0	0	0	0	2.0
5	BSSC101N	Essence of Traditional Knowledge	Online Course	1.0	0	0	0	0	2.0
6	BSSC102N	Indian Constitution	Online Course	1.0	0	0	0	0	2.0

BCHY101L	Engineering Chemistry	L	T	P	C
		3	0	0	3
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives

1. To enable students to have fundamental understanding of the basic concepts of different disciplines of chemistry.
2. To provide avenues for learning advanced concepts from school to university
3. To empower students with emerging concepts in applied chemistry to be useful in addressing societal needs
4. To integrate analytical and computational ability with experimental skills to create individuals competent in basic science and its by-product of its application.
5. To offer opportunities to create pathways for self-reliant in terms of knowledge and higher learning

Course Outcomes :

1. Understand the fundamental concepts in organic, inorganic, physical, and analytical chemistry.
2. Analyze the principles of applied chemistry in solving the societal issues.
3. Apply chemical concepts for the advancement of materials.
4. Appreciate the fundamental principles of spectroscopy and the related applications.
5. Design new materials, energy conversion devices and new protective coating techniques.

Module:1	**Chemical thermodynamics and kinetics**	**6 hours**

Laws of thermodynamics - entropy change (selected processes) – spontaneity of a chemical reaction and Gibbs free energy - heat transfer; Kinetics - Concept of activation energy and energy barrier - Arrhenius equation- effect of catalysts (homo and heterogeneous) – Enzyme catalysis (Michaelis-Menten Mechanism).

Module:2	**Metal complexes and organometallics**	**6 hours**

Inorganic complexes - structure, bonding and application; Organometallics – introduction, stability, structure and applications of metal carbonyls, ferrocene and Grignard reagent; Metals in biology (haemoglobin, chlorophyll- structure and property).

Module:3	**Organic intermediates and reaction transformations**	**6 hours**

Organic intermediates - stability and structure of carbocations, carbanions and radicals; Aromatics (aromaticity) and heterocycles (3, 4, 5, 6 membered and fused systems); Organic transformations for making useful drugs for specific disease targets (two examples) and dyes (addition, elimination, substitution and cross coupling reactions).

Module:4	**Energy devices**	**6 hours**

Electrochemical and electrolytic cells – electrode materials with examples (semi-conductors), electrode-electrolyte interface- chemistry of Li ion secondary batteries, supercapacitors; Fuel cells: H_2-O_2 and solid oxide fuel cell (SOFC); Solar cells - photovoltaic cell (silicon based), photoelectrochemical cells and dye-sensitized cells.

Module:5	**Functional materials**	**7 hours**

Oxides of AB, AB_2, ABO_3 type (specific examples); Composites - types and properties; Polymers - thermosetting and thermoplastic polymers – synthesis and application (TEFLON, BAKELITE); Conducting polymers- polyacetylene and effect of doping – chemistry of display devices specific to OLEDs; Nano materials – introduction, bulk *vs* nano (quantum dots), top-down and bottom-up approaches for synthesis, and properties of nano Au.

Module:6	**Spectroscopic, diffraction and microscopic techniques**	**5 hours**

Fundamental concepts in spectroscopic and instrumental techniques; Principle and applications of UV-Visible and XRD techniques (numericals); Overview of various techniques such as AAS, IR, NMR, SEM and TEM.

Module:7	**Industrial applications**	**7 hours**

Water purification methods - zeolites, ion-exchange resins and reverse osmosis; Fuels and combustion -LCV, HCV, Bomb calorimeter (numericals), anti-knocking agents); Protective coatings for corrosion control: cathodic and anodic protection - PVD technique; Chemical sensors for environmental monitoring - gas sensors; Overview of computational methodologies: energy minimization and conformational analysis.		
Module:8	**Contemporary topics**	**2 hours**
Guest lectures from Industry and, Research and Development Organizations		
	Total Lecture hours:	**45 hours**

Textbook	
1.	Theodore E. Brown, H Eugene, LeMay Bruce E. Bursten, Catherine Murphy, Patrick Woodward, Matthew E. Stoltzfus, Chemistry: The Central Science, 2017, 14th edition, Pearson Publishers, 2017. UK
Reference Books	
1.	Peter Vollhardt, Neil Schore, Organic Chemistry: Structure and Function, 2018, 8th ed. WH Freeman, London
2.	Atkins' Physical Chemistry: International, 2018, Eleventh edition, Oxford University Press; UK
3.	Colin Banwell, Elaine McCash, Fundamentals for Molecular Spectroscopy, 4th Edition, McGraw Hill, US
4.	Solid State Chemistry and its Applications, Anthony R. West. 2014, 2nd edition, Wiley, UK.
5.	AngÃ¨le Reinders, Pierre Verlinden, Wilfried van Sark, Alexandre Freundlich, Photovoltaic solar energy: From fundamentals to Applications, 2017, Wiley publishers,
6.	UK. Lawrence S. Brown and Thomas Holme, Chemistry for engineering students, 2018, 4th edition – *Open access version*

Mode of Evaluation: CAT, Written assignment, Quiz and FAT			
Recommended by Board of Studies	28.06.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BCHY101P	Engineering Chemistry Lab	L	T	P	C
		0	0	2	1
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objective

To apply theoretical knowledge gained in the theory course and get hands-on experience of the topics.

Course Outcome :

At the end of the course the student will be able to

1. Understand the importance and hands-on experience on analysis of metal ions by means of experiments.
2. Get practical experience on synthesis and characterization of the organic molecules and nanomaterials in the laboratory.
3. Apply their knowledge in thermodynamic functions, kinetics and molecular geometries through the experiments.

Indicative Experiments	
1.	Thermodynamics functions from EMF measurements : Zinc – Copper system
2.	Determination of reaction rate, order and molecularity of ethylacetate hydrolysis
3.	Colorimetric estimation of Ni^{2+} using conventional and smart phone digital-imaging methods
4.	Laboratory scale preparation of important drug intermediate - para aminophenol for the synthesis for acetaminophen
5.	Magnesium-sea water activated cell – Effect of salt concentration on voltage generation
6.	Analysis of iron in an alloy sample by potentiometry
7.	Preparation of tin oxide by sol- gel method and its characterization
8.	Size dependent colour variation of Cu_2O nanoparticles by spectrophotometer
9.	Determination of hardness of water sample by complexometric titration before and after ion-exchange process
10.	Computational Optimization of molecular geometry using Avogadro software
	Total Laboratory Hours **30 hours**

Mode of assessment: Mode of assessment: Continuous assessment / FAT / Oral examination and others

Recommended by Board of Studies	28.06.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BCSE101E	Computer Programming: Python	L	T	P	C
		1	0	4	3
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives

1. To provide exposure to basic problem-solving techniques using computers.
2. To inculcate the art of logical thinking abilities and propose novel solutions for real world problems through programming language constructs.

Course Outcome

1. Classify various algorithmic approaches, categorize the appropriate data representation, and demonstrate various control constructs.
2. Choose appropriate programming paradigms, interpret and handle data using files to propose solution through reusable modules; idealize the importance of modules and packages.

Module:1	**Introduction to Problem Solving**	**1 hour**

Problem Solving: Definition and Steps, Problem Analysis Chart, Developing an Algorithm, Flowchart and Pseudocode.

Module:2	**Python Programming Fundamentals**	**2 hours**

Introduction to python – Interactive and Script Mode – Indentation – Comments – Variables – Reserved Words – Data Types – Operators and their precedence – Expressions – Built-in Functions – Importing from Packages.

Module:3	**Control Structures**	**2 hours**

Decision Making and Branching: if, if-else, nested if, multi-way if-elif statements – Looping: while loop, for loop – else clauses in loops, nested loops – break, continue and pass statements.

Module:4	**Collections**	**3 hours**

Lists: Create, Access, Slicing, Negative indices, List methods, List comprehensions – Tuples: Create, Indexing and slicing, Operations on tuples – Dictionary: Create, add, and replace values, Operations on dictionaries – Sets: Creation and operations.

Module:5	**Strings and Regular Expressions**	**2 hours**

Strings: Comparison, Formatting, Slicing, Splitting, Stripping – Regular Expressions: Matching,
Search and replace, Patterns.

Module:6	**Functions and Files**	**3 hours**

Functions – Parameters and Arguments: Positional arguments, Keyword arguments, Parameters
with default values – Local and Global scope of variables – Functions with Arbitrary arguments – Recursive Functions – Lambda Function. Files: Create, Open, Read, Write, Append and Close – tell and seek methods.

Module:7	**Modules and Packages**	**2 hours**

Built-in modules – User-Defined modules – Overview of Numpy and Pandas packages.

	Total Lecture hours:	**15 hours**

Text Book(s)

1.	Eric Matthes, Python Crash Course: A Hands-On, Project-Based Introduction to Programming, 2nd Edition, No starch Press, 2019

Reference Books

1.	Martic C Brown, Python: The Complete Reference, 4th Edition, McGraw Hill Publishers, 2018.
2.	John V. Guttag, Introduction to computation and programming using python: with applications to understanding data. 2nd Edition, MIT Press, 2016.

Mode of Evaluation: No separate evaluation for theory component.			
Indicative Experiments			
1.	Problem Analysis Chart, Flowchart and Pseudocode Practices.		
2.	Sequential Constructs using Python Operators, Expressions.		
3.	Branching (if, if-else, nested if, multi-way if-elif statements) and Looping (for, while, nested looping, break, continue, else in loops).		
4.	List, Tuples, Dictionaries & Sets.		
5.	Strings, Regular Expressions.		
6.	Functions, Lambda, Recursive Functions and Files.		
7.	Modules and Packages (NumPy and Pandas)		
Total Laboratory Hours			**60 hours**
Text Book(s)			
1.	Mariano Anaya, Clean Code in Python: Develop maintainable and efficient code, 2nd Edition, Packt Publishing Limited, 2021.		
Reference Books			
1.	Harsh Bhasin, Python for beginners, 1st Edition, New Age International (P) Ltd., 2019,		
	Mode of assessment: Continuous assessments and FAT		
Recommended by Board of Studies	03.07.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BCSE103E	Computer Programming : Java	L	T	P	C
		1	0	4	3
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. To introduce the core language features of Java and understand the fundamentals of Object -Oriented programming in Java.
2. To develop the ability of using Java to solve real world problems.

Course Outcome:

At the end of this course, students should be able to:

1. Understand basic programming constructs; realize the fundamentals of Object Orientated Programming in Java; apply inheritance and interface concepts for enhancing code reusability.
2. Realize the exception handling mechanism; process data within files and use the data structures in the collection framework for solving real world problems.

Module:1	**Java Basics**	**2 hours**

OOP Paradigm - Features of Java Language - JVM - Bytecode - Java program structure – Basic programming constructs - data types - variables – Java naming conventions – operators.

Module:2	**Looping Constructs and Arrays**	**2 hours**

Control and looping constructs - Arrays – one dimensional and multi-dimensional – enhanced for loop – Strings - Wrapper classes.

Module:3	**Classes and Objects**	**2 hours**

Class Fundamentals – Access and non-access specifiers - Declaring objects and assigning object reference variables – array of objects – constructors and destructors – usage of "this" and "static" keywords.

Module:4	**Inheritance and Polymorphism**	**3 hours**

Inheritance – types –- use of "super" – final keyword - Polymorphism – Overloading and Overriding - abstract class – Interfaces.

Module:5	**Packages and Exception Handling**	**2 hours**

Packages: Creating and Accessing - Sub packages.
Exception Handling - Types of Exception - Control Flow in Exceptions - Use of try, catch, finally, throw, throws in Exception Handling - User defined exceptions.

Module:6	**IO Streams and Files**	**2 hours**

Java I/O streams – FileInputStream & FileOutputStream – FileReader & FileWriter- DataInputStream & DataOutputStream – BufferedInputStream & BufferedOutputStream – PrintOutputStream - Serialization and Deserialization.

Module:7	**Collection Framework**	**2 hours**

Generic classes and methods - Collection framework: List and Map.

	Total Lecture hours:	**15 hours**

Text Book(s)

1.	Y. Daniel Liang, "Introduction to Java programming" - comprehensive version-11th Edition, Pearson publisher, 2017.

Reference Books

1.	Herbert Schildt , The Complete Reference -Java, Tata McGraw-Hill publisher, 10th Edition, 2017.
2	Cay Horstmann,"Big Java", 4th edition, John Wiley & Sons publisher, 5th edition, 2015
3	E.Balagurusamy, "Programming with Java", Tata McGraw-Hill publishers, 6th edition, 2019

Mode of Evaluation: No separate evaluation for theory component.			
Indicative Experiments			
1.	Programs using sequential and branching structures.		
2.	Experiment the use of looping, arrays and strings.		
3.	Demonstrate basic Object-Oriented programming elements.		
4.	Experiment the use of inheritance, polymorphism and abstract classes.		
5.	Designing packages and demonstrate exception handling.		
6.	Demonstrate the use of IO streams, file handling and serialization.		
7.	Program to discover application of collections.		
	Total Laboratory Hours	**60 hours**	
Text Book(s)			
1.	Marc Loy, Patrick Niemeyer and Daniel Leuck, Learning Java, O'Reilly Media, Inc., 5th Edition, 2020.		
Reference Books			
1.	Dhruti Shah, 100+ Solutions in Java: A Hands-On Introduction to Programming in Java, BPB Publications, 1st Edition, 2020.		
Mode of assessment: Continuous assessments and FAT			
Recommended by Board of Studies		03.07.2021	
Approved by Academic Council	No. 63	Date	23.09.2021

BECE101L	Basic Electronics	L	T	P	C
		2	0	0	2
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To introduce the students to the basic concepts of electronic components, sources, measurements. and instrumentation.
2. To apply the inculcated knowledge for developing simple circuits using various electronic components and devices
3. To familiarize the students with the basic concepts of number systems and digital logic.
4. To analyse the concepts associated with multiple sensors and their sensing mechanisms.

Course Outcome

Students will be able to

1. Understand the basic electronic components, sources, and measuring equipment
2. Comprehend the characteristics of diodes, transistors and their applications
3. Design and analyse the amplifiers and oscillators
4. Design and implement simple digital circuits
5. Analyse the performance metrics of the measurement systems.
6. Comprehend the basic concept of various sensors and their sensing mechanisms.

Module:1	**Electronic Components, Sources, and Measuring Equipment**	**3 hours**

Evolution of Electronics – Impact of Electronics in Industry and Society – Familiarization of Resistors, Capacitors, Inductors – Colour Coding – types and specifications, – Electro-mechanical components – Relay and Contactors – Regulated Power supply, Function Generator – Multimeter – CRO

Module:2	**Junction Diodes**	**4 hours**

Intrinsic and extrinsic semiconductors – doping - PN Junctions, Formation of Junction, Physical operation of diode, Barrier Potential, I - V Characteristics, Rectifiers, Zener diode – I-V Characteristics, Zener diode as Voltage regulator.

Module:3	**Transistors**	**5 hours**

Bipolar Junction Transistor (BJT) - Device structure and physical operation, Concept of CB, CE and CC Configuration, Transistor as a Switch, - Metal-Oxide Field Effect Transistor (MOSFET) - Device Structure, mode of operation and Characteristics, MOSFET configurations (CS, CD, CG).

Module:4	**Amplifiers and Oscillators**	**4 hours**

BJT as an amplifier (CE configuration), MOSFET as an amplifier (CS configuration), Feedback concept, Oscillators - Barkhaunsen's criteria for sustained oscillation, RC Phase Shift Oscillator, LC Oscillator.

Module:5	**Digital Logics**	**4 hours**

Number systems, conversion of bases, Boolean algebra, Logic Gates, Concept of universal gate, Simplification and implementation of Boolean functions.

Module:6	**Principles of Measurement and Analysis**	**3 hours**

Units and standards, Errors, Functional Elements of a Measurement System and Instruments, Applications and Classification of Instruments, Types of measured Quantities, Measures of Dispersion, Sample deviation and sample mean, Calibration and standard.

Module:7	**Sensors and Transducers**	**5 hours**

Sensor fundamentals and characteristics - General concepts and terminology of measurement systems, Sensors and transducers - Classification of sensors, Static and dynamic characteristics. Principle of Resistive Sensors, Capacitive Sensors, Inductive Sensors, Magnetic sensors, Optical sensor, Self-generating Sensors

Module:8	**Contemporary issues**	**2 hours**

Guest lectures from Industry and, Research and Development Organisations

	Total Lecture hours:	**30 hours**

Text Book(s)			
1.	A. P. Malvino, D. J. Bates, Electronic Principles, 2017, 7/e, Tata McGraw-Hill.		
2	Albert D. Helfrick and William D. Cooper, "Modern Electronic Instrumentation and Measurement Techniques", 2016, First Edition, Pearson Education, Noida, India.		
Reference Books			
1.	David A Bell, Electronic Devices and Circuits, Oxford Press, 5th Edition, 2008		
2	Robert L. Bolysted and Louis Nashelsky, Electronic Devices and Circuit Theory, Prentice Hall of India, 11th Edition, 2017		
3	D. Patranabis – Sensor and Transducers (2e) Prentice Hall, New Delhi, 2003		
4	A.K. Sawhney, Puneet Sawhney, A Course In Electrical and Electronic Measurements, and Instrumentation, Dhanpat Rai & Co., 2015		
Mode of Evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & FAT			
Recommended by Board of Studies	08.07.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BECE101P	Basic Electronics Lab	L	T	P	C
		0	0	2	1
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To learn the various characteristics of diodes and transistors
2. To understand the concept of digital logic functions and verify the truth tables
3. To learn the performance metrics of measurement systems and characteristics of various sensors

Course Outcome

Students will be able to
1. Analyse the various characteristics and applications of diodes and transistors
2. Design logic circuits using logic gates and verify their truth tables
3. Measure the physical parameters using different transducers

Indicative Experiments

1	Identify, mark the terminal and find the value of a particular component from the given group of electronic components, Study of electronic measurement devices (Multimeter, DSO, function generator)
2	V-I Characteristics of PN Junction diodes and Zener diodes
3	Half Wave and Full Wave Rectifier circuits
4	Zener Diode as a voltage regulator
5	Characteristics of BJT in Common Emitter Configuration
6	Characteristics of MOSFET in Common Source Configuration
7	Frequency response of BJT single stage amplifier
8	Study of the signal generation using RC Phase Shift Oscillator
9	Study of logic gates and implementation of Boolean Functions
10	Strain gauge sensors for measurement of normal strain.
11	Displacement measurement using LVDT and LDR.
12	Temperature measurement using RTD, Thermistor and Thermocouple.

Total Laboratory Hours **30 hours**

Text Book(s)

1.	A. P. Malvino, D. J. Bates, Electronic Principles, 2017, 7/e, Tata McGraw-Hill.
2	Albert D. Helfrick and William D. Cooper, "Modern Electronic Instrumentation and Measurement Techniques", 2016, First Edition, Pearson Education, Noida, India.

Reference Books

1.	Robert L. Bolysted and Louis Nashelsky, Electronic Devices and Circuit Theory, Prentice Hall of India, 11th Edition, 2017
2	D. Patranabis – Sensor and Transducers (2e) Prentice Hall, New Delhi, 2003

Mode of assessment: Continuous assessment / FAT / Oral examination and others

Recommended by Board of Studies	08.07.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BEEE101L	Basic Electrical Engineering	L	T	P	C
		2	0	0	2
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives

1. Provide insights into relevant concepts and principles in electrical engineering
2. Facilitate understand and comprehend laws, rules and theorems to compute parameters of electric circuits
3. Enable comprehend and analyze the concepts of electrical machines and measuring instruments

Course Outcome

On completion of this course, the students will be able to

1. Evaluate DC and AC circuit parameters using various laws and theorems
2. Analyze the parameters of magnetically coupled circuits and compare various types of electrical machines
3. Comprehend the measurement techniques of electrical parameters
4. Understand the concept of electric supply system and comprehend essential electrical safety requirements

Module:1	**DC Circuits**	**6 hours**

Basic circuit elements and sources; Ohms law, Kirchhoff's laws; Series and parallel connection of circuit elements; Source transformation; Node voltage analysis; Mesh current analysis; Maximum power transfer theorem

Module:2	**AC Circuits**	**6 hours**

Alternating voltages and currents, RMS, average, form factor, peak factor; Single phase RL, RC, RLC series and parallel circuits; Power and power factor; Balanced three phase systems

Module:3	**Magnetic Circuits**	**4 hours**

Electromagnetic Induction: Self and mutual; Magnetically coupled circuits; Series and parallel magnetic circuits; Dot convention

Module:4	**Electrical Machines**	**5 hours**

Principle of operation, construction and applications of DC machines, transformers, induction motors, synchronous generators, stepper motor, Brushless DC (BLDC) motor

Module:5	**Electrical Measurements**	**4 hours**

Principle, Construction and operation of moving coil and moving iron instruments; Power and energy measurement in single phase and three phase systems

Module: 6	**Electrical Supply Systems & Safety**	**3 hours**

Concepts of electrical power generation, transmission and distribution systems; Wiring; Electrical safety; Earthing; Protective devices

Module: 7	**Contemporary Issues**	**2 hours**

Guest lectures from Industry and, Research and Development Organizations

	Total Lecture hours:	**30 hours**

Text Book(s)

1. Allan R. Hambley, Electrical Engineering: Principles & Applications, 2019, 7th edition, Pearson Education

Reference Books

1. DP Kothari & I J Nagrath, Basic Electric Engineering, 2019, 4th edition, McGraw Hill Education
2. John Bird, Electrical Circuit Theory and Technology, 2013, 5th edition, Routledge Publications
3. S. Salivahnan, R Rengaraj, G R Venkatakrishnan, Basic Electrical, Electronics and Measurement Engineering, 2018, McGraw Hill Education
4. E.W Golding, F.C Widdis, Electrical Measurements and Measuring Instruments,

	2011, Reem Publications		
5.	V K Mehta and Rohit Mehta, Principles of Power System, 2005, S. Chand		
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT			
Recommended by Board of Studies	03.07.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BEEE101P	Basic Electrical Engineering Lab	L	T	P	C
		0	0	2	1
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives

1. Understanding the concepts of electrical engineering for development and implementation of electrical systems
2. Impart knowledge and skill in wiring and its standards
3. Facilitate comprehend and identify appropriate measuring devices for an electric circuit

Course Outcome

On completion of this course, the students will be able to

1. Understand, analyze and validate the electric circuit parameters
2. Design and develop electrical systems for domestic and commercial applications
3. Acquire skills for interpretation of measurement during experimentation
4. Attain skills to use modern engineering tools for electrical system layout planning

Indicative Experiments	
1	Verification of Kirchhoff's voltage law
2	Verification of Kirchhoff's current law
3	Verification of maximum power transfer theorem
4	Sinusoidal steady state response of RLC circuits
5	Wiring circuit for a single lamp and a fan with regulator
6	Wiring circuit for Godown with two-way switch
7	Load test on single phase transformer/DC motor
8	Measurement of power in a single phase AC Load
9	Measurement of power and energy consumed by a given three phase AC load
10	Study of earthing and measurement of earth pit resistance
11	Cost estimation of residential electrical wiring
12	Electrical layout for a residential/commercial/industrial application using CAD software
	Total Laboratory Hours **30 hours**

Text Book(s)	
1	Allan R. Hambley, Electrical Engineering: Principles & Applications, 2019, 7th edition, Pearson Education

Mode of assessment: CAT, FAT, Oral examination

Recommended by Board of Studies	03.07.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BENG101L	Technical English Communication	L	T	P	C
		2	0	0	2
Pre-requisite	NIL	**Syllabus version**			
		1.0			

Course Objectives:

1. To develop LSRW skills for effective communication in professional situations
2. To enhance knowledge of grammar and vocabulary for meaningful communication
3. To understand information from diverse texts for effective technical communication

Course Outcomes:

1. Use grammar and vocabulary appropriately while writing and speaking
2. Apply the concepts of communication skills in formal and informal situations
3. Demonstrate effective reading and listening skills to synthesize and draw intelligent inferences
4. Write clearly and significantly in academic and general contexts

Module:1	**Introduction to Communication**	**4 hours**
Nature and Process - Types of communication: Intra-personal, Interpersonal, Group-verbal and non-verbal communication / Cross-cultural Communication - Communication Barriers and Essentials of good communication - Principles of Effective Communications		
Module:2	**Grammatical Aspects**	**4 hours**
Sentence Pattern - Modal Verbs - Concord (SVA) - Conditionals - Error detection		
Module:3	**Written Correspondence**	**4 hours**
Job Application Letters - Resume Writing - Statement of Purpose		
Module:4	**Business Correspondence**	**4 hours**
Business Letters: Calling for Quotation, Complaint & Sales Letter – Memo - Minutes of Meeting - Describing products and processes		
Module:5	**Professional Writing**	**4 hours**
Paraphrasing & Summarizing - Executive Summary - Structure and Types of Proposal – Recommendations		
Module:6	**Team Building & Leadership Skills**	**4 hours**
Principles of Leadership - Team Leadership Model - Negotiation Skills - Conflict Management		
Module:7	**Research Writing**	**4 hours**
Interpreting and Analysing a research article - Approaches to Review Paper Writing - Structure of a research article - Referencing		
Module:8	**Guest Lecture from Industry and R&D organizations**	**2 hours**
Contemporary Issues		
	Total Lecture hours:	**30 hours**

Text Book(s)

1. Raman, Meenakshi & Sangeeta Sharma. (2015). *Technical Communication: Principles and Practice*, (3rd Edition). India: Oxford University Press.

Reference Books

1. Taylor, Shirley & Chandra .V. (2010). *Communication for Business A Practical Approach* 4th Edition. India: Pearson Longman.
2. Kumar, Sanjay & Pushpalatha. (2018). *English Language and Communication Skills for Engineers.* India: Oxford University Press.
3. Koneru Aruna. (2020*). English Language Skills for Engineers.* India: McGraw Hill Education.
4. Rizvi, M. Ashraf. (2018). *Effective Technical Communication* 2nd Edition. Chennai: McGraw Hill Education.
5. Mishra, Sunitha & Muralikrishna,C. (2014). *Communication Skills for Engineers*. India: Pearson Education.

6.	Watkins, P. (2018). *Teaching and Developing Reading Skills: Cambridge Handbooks for Language teachers*. India: Cambridge University Press.		
Mode of Evaluation : CAT / Assignment / Quiz / FAT / Group Discussion			
Recommended by Board of Studies	28.06.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BENG101P	Technical English Communication Lab	L	T	P	C
		0	0	2	1
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. To use appropriate grammatical structures in professional communication
2. To improve English communication skills for better employability
3.To enhance meaningful communication skills in writing and public speaking

Course Outcomes:

1.Demonstrate professional rhetoric and articulate ideas effectively
2. Interpret material on technology and deliver eloquent presentations
3. Apply receptive and productive skills in real life situations and develop workplace communication

Indicative Experiments

1.	**Grammar & Vocabulary** Error Detection **Activity:** -Worksheets
2.	**Listening to Narratives** Interviews of eminent personalities & Ted Talks **Activity:** Listening Comprehension / Summarising
3.	**Video Resume** SWOT Analysis & digital resume techniques **Activity:** Preparing a digital résumé for mock interview
4.	**Product & Process Description** Describing and Sequencing **Activity:** Demonstration of product and process
5.	**Mock Meetings** Types of meetings and meeting etiquette **Activity: Conduct of meetings and drafting minutes of the meeting**
6.	**Reading research article** Scientific and Technical articles **Activity:** Writing Literature review
7.	**Analytical Reading** Case Studies on Communication, Team Building and Leadership **Activity:** Group Discussion
8.	**Presentations** Preparing Conference/Seminar paper **Activity:** Individual/ Group presentations
9.	**Intensive Listening** Scientific documentaries **Activity:** Note taking and Summarising
10.	**Interview Skills** Interview questions and techniques **Activity:** Mock Interviews

Total Laboratory Hours	**30 hours**

Mode of Assessment: Continuous Assessment / FAT / Written Assignments / Quiz/ Oral Presentation and Group Activity.

Recommended by Board of Studies	28.06.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BENG102P	Technical Report Writing	L	T	P	C
		0	0	2	1
Pre-requisite	Technical English Communication	**Syllabus version**			
		1.0			

Course Objectives:

1. To augment specific writing skills for preparing technical reports
2. To think critically, evaluate, analyse general and complex technical information
3. To acquire proficiency in writing and presenting reports

Course Outcomes:

1.Write error free sentences using appropriate grammar, vocabulary and style
2. Synthesize information and concepts in preparing reports
3. Demonstrate the ability to write and present reports on diverse topics

Indicative Experiments

1.	**Advanced Grammar, Vocabulary and Editing** Usage of Tenses - Adjectives and Adverbs - Jargon vs Technical Vocabulary – Abbreviations - Mechanics of Editing: Punctuation and Proof Reading **Activity:** Worksheets
2.	**Research and Analyses** Synchronise Technical Details from Newspapers - Magazines - Articles and e-content **Activity**: Writing introduction and literature review
3.	**Systematisation of Information** Techniques to Converge Objective-Oriented data in Diverse Technical Reports **Activity:** Preparing Questionnaire
4.	**Data Visualisation** Interpreting Data - Graphs - Tables – Charts - Imagery - Infographics **Activity:** Transcoding
5.	**Introduction to Reports** Meaning - Definition - Purpose - Characteristics and Types of Reports **Activity:** Worksheets on Types of reports
6.	**Structure of Reports** Title – Preface – Acknowledgement - Abstract/Summary – Introduction - Materials and Methods – Results – Discussion - Conclusion - Suggestions/Recommendations **Activity:** Identifying the structure of report
7.	**Report Writing** Data Collection - Draft an Outline and Organize Information **Activity:** Drafting reports
8.	**Supplementary Texts** Appendix – Index – Glossary – References – Bibliography - Notes **Activity:** Organizing supplementary texts
9.	**Review of Final Reports** Structure – Content – Style - Layout and Referencing **Activity:** Examining clarity and coherence in final reports
10.	**Presentation** Presenting Technical Reports **Activity:** Planning, creating and digital presentation of reports
	Total Laboratory Hours **30 hours**

Mode of assessment: Continuous Assessment / FAT / Assignments / Quiz / Presentations / Oral examination

Recommended by Board of Studies	28.06.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BMAT101L	Calculus	L	T	P	C
		3	0	0	3
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To provide the requisite and relevant background necessary to understand the other important engineering mathematics courses offered for Engineers and Scientists.
2. To introduce important topics of applied mathematics, namely Single and Multivariable Calculus and Vector Calculus etc.
3. Enhance to use technology to model the physical situations into mathematical problems, experiment, interpret results, and verify conclusions.

Course Outcomes

At the end of the course the student should be able to:
1. Apply single variable differentiation and integration to solve applied problems in engineering and find the maxima and minima of functions
2. Evaluate partial derivatives, limits, total differentials, Jacobians, Taylor series and optimization problems involving several variables with or without constraints
3. Evaluate multiple integrals in Cartesian, Polar, Cylindrical and Spherical coordinates.
4. Use special functions to evaluate various types of integrals.
5. Understand gradient, directional derivatives, divergence, curl, Green's, Stokes and Gauss Divergence theorems.

Module:1	**Single Variable Calculus**	**8 hours**

Differentiation- Extrema on an Interval Rolle's Theorem and the Mean value theorem-Increasing and decreasing functions.-First derivative test-Second derivative test-Maxima and Minima-Concavity. Integration-Average function value - Area between curves - Volumes of solids of revolution.

Module:2	**Multivariable Calculus**	**5 hours**

Functions of two variables-limits and continuity-partial derivatives –total differential-Jacobian and its properties.

Module:3	**Application of Multivariable Calculus**	**5 hours**

Taylor's expansion for two variables–maxima and minima–constrained maxima and minima-Lagrange's multiplier method.

Module:4	**Multiple integrals**	**8 hours**

Evaluation of double integrals–change of order of integration–change of variables between Cartesian and polar co-ordinates - evaluation of triple integrals-change of variables between Cartesian and cylindrical and spherical co-ordinates.

Module:5	**Special Functions**	**6 hours**

Beta and Gamma functions–interrelation between beta and gamma functions-evaluation of multiple integrals using gamma and beta functions. Dirichlet's integral -Error functions complementary error functions.

Module:6	**Vector Differentiation**	**5 hours**

Scalar and vector valued functions – gradient, tangent plane–directional derivative-divergence and curl–scalar and vector potentials. Statement of vector identities-simple problems.

Module:7	**Vector Integration**	**6 hours**

Line, surface and volume integrals - Statement of Green's, Stoke's and Gauss divergence theorems -verification and evaluation of vector integrals using them.

Module:8	**Contemporary Topics**	**2 hours**

Guest lectures from Industry and, Research and Development Organizations

	Total Lecture hours:	**45 hours**

Text Book

1. George B.Thomas, D.Weir and J. Hass, Thomas Calculus, 2014, 13th edition, Pearson

Reference Books				
1.	Erwin Kreyszig, Advanced Engineering Mathematics, 2015, 10th Edition, Wiley India			
2.	B.S. Grewal, Higher Engineering Mathematics, 2020, 44th Edition, Khanna Publishers			
3.	John Bird, Higher Engineering Mathematics, 2017, 6th Edition, Elsevier Limited.			
4.	James Stewart, Calculus: Early Transcendental, 2017, 8th edition, Cengage Learning.			
5.	K.A.Stroud and Dexter J. Booth, Engineering Mathematics, 2013, 7th Edition, Palgrave Macmillan.			
Mode of Evaluation: CAT, Assignment, Quiz and FAT				
Recommended by Board of Studies		24.06.2021		
Approved by Academic Council		No. 63	Date	23.09.2021

BMAT101P	**Calculus Lab**	**L**	**T**	**P**	**C**
		0	**0**	**2**	**1**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives

1. To familiarize with the basic syntax, semantics and library functions of MATLAB which serves as a tool not only in calculus but also many courses in engineering and sciences
2. To visualize mathematical functions and its related properties.
3. To evaluate single and multiple integrals and understand it graphically.

Course Outcomes

At the end of the course the student should be able to:
1. Demonstrate MATLAB code for challenging problems in engineering
2. Using plots/displays, interpret and illustrate elementary mathematical functions and procedures.

Indicative Experiments	
1.	Introduction to MATLAB through matrices and general Syntax
2.	Plotting and visualizing curves and surfaces in MATLAB – Symbolic computations using MATLAB
3.	Evaluating Extremum of a single variable function
4.	Understanding integration as Area under the curve
5.	Evaluation of Volume by Integrals (Solids of Revolution)
6.	Evaluating maxima and minima of functions of two variables
7.	Applying Lagrange multiplier optimization method
8.	Evaluating Volume under surfaces
9.	Evaluating triple integrals
10.	Evaluating gradient, curl and divergence
11.	Evaluating line integrals in vectors
12.	Applying Green's theorem to real world problems
	Total Laboratory Hours **30 hours**

Text Book

1.	Brian H. Hahn, Daniel T. Valentine, Essential MATLAB for Engineers and Scientists, Academic Press, 7th edition, 2019.

Reference Books

1.	Amos Gilat, MATLAB: An Introduction with Applications, Wiley, 6/e, 2016.
2	Maritn Brokate, Pammy Manchanda, Abul Hasan Siddiqi, Calculus for Scientists and Engineers, Springer, 2019

Mode of assessment: DA and FAT			
Recommended by Board of Studies	24.06.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BMAT102L	Differential Equations and Transforms	L	T	P	C
		3	1	0	4
Pre-requisite	**BMAT101L, BMAT101P**	**Syllabus version**			
		1.0			

Course Objectives

1. To impart the knowledge of Laplace transform, an important transform techniques for Engineers which requires knowledge of integration.
2. Presenting the elementary notions of Fourier series, this is vital in practical harmonic analysis.
3. Enriching the skills in solving initial and boundary value problems.
4. Impart the knowledge and application of difference equations and the Z-transform in discrete systems that are inherent in natural and physical processes.

Course Outcomes

At the end of the course the student should be able to:

1. Find solution for second and higher order differential equations, formation and solving partial differential equations.
2. Understand basic concepts of Laplace Transforms and solve problems with periodic functions, step functions, impulse functions and convolution.
3. Employ the tools of Fourier series and Fourier transforms.
4. Know the techniques of solving differential equations and partial differential equations.
5. Know the Z-transform and its application in population dynamics and digital signal processing.

Module:1	**Ordinary Differential Equations (ODE)**	**6 hours**

Second order non- homogenous differential equations with constant coefficients- Differential equations with variable coefficients- method of undetermined coefficients-method of Variation of parameters-Solving Damped forced oscillations and LCR circuit theory problems.

Module:2	**Partial Differential Equations (PDE)**	**5 hours**

Formation of partial differential equations – Singular integrals — Solutions of standard types of first order partial differential equations – Lagrange's linear equation-Method of separation of variables

Module:3	**Laplace Transform**	**7 hours**

Definition- Properties of Laplace transform-Laplace transform of standard functions - Laplace transform of periodic functions-Unit step function-Impulse function. Inverse Laplace transform-Partial fractions method and by Convolution theorem..

Module:4	**Solution to ODE and PDE by Laplace transform**	**7 hours**

Solution of ODE's – Non-homogeneous terms involving Heaviside function, Impulse function - Solving Non-homogeneous system using Laplace transform - solution to First order PDE by Laplace transform.

Module:5	**Fourier Series**	**6 hours**

Fourier series - Euler's formulae- Dirichlet's conditions - Change of interval - Half range series – RMS value – Parseval's identity.

Module:6	**Fourier Transform**	**6 hours**

Complex Fourier transform - properties - Relation between Fourier and Laplace Transforms- Fourier sine and cosine transforms – Parseval's identity- Convolution Theorem and simple applications to solve PDE.

Module:7	**Z-Transform**	**6 hours**

Definition of Z-transform and Inverse Z-transform - Standard functions - Partial fractions and

convolution method. Difference equation - first and second order difference equations with constant coefficients - solution of simple difference equations using Z-transform.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours: **Total Tutorial hours :**	**45 hours** **15 hours**

Text Book(s)

1. Erwin Kreyszig, Advanced Engineering Mathematics, 2015, 10th Edition, John Wiley India.
2. B.S. Grewal, Higher Engineering Mathematics, 2020, 44th Edition, Khanna Publishers.

Reference Books

1. Michael D. Greenberg, Advanced Engineering Mathematics, 2006, 2nd Edition, Pearson Education, Indian edition.
2. A First Course in Differential Equations with Modelling Applications, Dennis Zill, 2018, 11th Edition, Cengage Publishers.

Mode of Evaluation: CAT, written assignment, Quiz, FAT

Recommended by Board of Studies	24-06-2021		
Approved by Academic Council	No. 64	Date	16-12-2021

BMAT201L	Complex Variables and Linear Algebra	L	T	P	C
		3	1	0	4
Pre-requisite	**BMAT102L**	**Syllabus version**			
		1.0			

Course Objectives

1. To present comprehensive, compact, and integrated treatment of one of the most important branches of applied mathematics namely Complex variables to the engineers and the scientists.
2. To present comprehensive, compact, and integrated treatment of another most important branches of applied mathematics namely Linear Algebra to the engineers and the scientists.
3. To provide students with a framework of the concepts that will help them to analyse deeply about many complex problems.

Course Outcomes

At the end of the course the student should be able to

1. Construct analytic functions and find complex potential of fluid flow and electric fields.
2. Find the image of straight lines by elementary transformations and to express analytic functions in power series.
3. Evaluate real integrals using techniques of contour integration.
4. Use the power of inner product and norm for analysis.
5. Use matrices and transformations for solving engineering problems.

Module:1	**Analytic Functions**	**7hours**

Complex variable - Analytic functions and Cauchy – Riemann equations; Laplace equation and Harmonic functions; Construction of Harmonic conjugate and analytic functions; Applications of analytic functions to fluid-flow and electric field problems.

Module:2	**Conformal and Bilinear transformations**	**7 hours**

Conformal mapping - Elementary transformations; Translation, Magnification, Rotation, Inversion; Exponential and Square transformations ($w = e^z$, z^2); Bilinear transformation; Cross-ratio-Images of the regions bounded by straight lines under the above transformations;

Module:3	**Complex Integration**	**7 hours**

Functions given by Power Series - Taylor and Laurent series-Singularities - Poles – Residues; Integration of a complex function along a contour; Statements of Cauchy-Goursat theorem- Cauchy's integral formula-Cauchy's residue theorem-Evaluation of real integrals-Indented contour integral.

Module:4	**Vector Spaces**	**6 hours**

Vector space – subspace; linear combination - span - linearly dependent – Independent – bases; Dimensions; Finite dimensional vector space. Row and column spaces; Rank and nullity.

Module:5	**Linear Transformations**	**6 hours**

Linear transformations – Basic properties; Invertible linear transformation; Matrices of linear transformations; Vector space of linear transformations; Change of bases; Similarity.

Module:6	**Inner Product Spaces**	**5 hours**

Dot products and inner products; Lengths and angles of vectors; Matrix representations of inner products; Gram - Schmidt – Orthogonalization.

Module:7	**Matrices and System of Equations**	**5 hours**

Eigenvalues and Eigen vectors; Properties of Eigenvalues and Eigen vectors; Cayley-Hamilton theorem; System of linear equations; Gaussian elimination and Gauss Jordan methods.

Module:8	**Contemporary issues:**	**2 hours**

	Total Lecture hours: **Total Tutorial hours :**	**45 hours** **15 hours**

Text Book(s)

1. G. Dennis Zill, Patrick D. Shanahan, A first course in complex analysis with applications, 2013, 3rd Edition, Jones and Bartlett Publishers Series in Mathematics.
2. Jin Ho Kwak, Sungpyo Hong, Linear Algebra, 2004, Second edition, Springer.

Reference Books

1. Erwin Kreyszig, Advanced Engineering Mathematics, 2015, 10th Edition, John Wiley & Sons (Wiley student Edition).
2. Michael, D. Greenberg, Advanced Engineering Mathematics, 2006, 2nd Edition, Pearson Education.
3. Bernard Kolman, David, R. Hill, Introductory Linear Algebra - An applied first course, 2011, 9th Edition Pearson Education.
4. Gilbert Strang, Introduction to Linear Algebra, 2015, 5th Edition, Cengage Learning
5. B.S. Grewal, Higher Engineering Mathematics, 2020, 44th Edition, Khanna Publishers.

Mode of Evaluation: Digital Assignments(Solutions by using soft skill), Quiz, Continuous Assessments, Final Assessment Test.

Recommended by Board of Studies	24-06-2021		
Approved by Academic Council	No. 64	Date	16-12-2021

BMAT202L	Probability and Statistics	L	T	P	C
		3	0	0	3
Pre-requisite	**BMAT101L, BMAT101P**	**Syllabus version**			
		1.0			

Course Objectives :

1. To provide students with a framework that will help them choose the appropriate descriptive methods in various data analysis situations.
2. To analyze distributions and relationship of real-time data.
3. To apply estimation and testing methods to make inference and modelling techniques for decision making.

Course Outcome :

At the end of the course the student should be able to:

1. Compute and interpret descriptive statistics using numerical and graphical techniques.
2. Understand the basic concepts of random variables and find an appropriate distribution for analyzing data specific to an experiment.
3. Apply statistical methods like correlation, regression analysis in analyzing, interpreting experimental data.
4. Make appropriate decisions using statistical inference that is the central to experimental research.
5. Use statistical methodology and tools in reliability engineering problems.

Module:1	**Introduction to Statistics**	**6 hours**

Statistics and data analysis; Measures of central tendency; Measure of Dispersion, Moments-Skewness-Kurtosis (Concepts only).

Module:2	**Random variables**	**8 hours**

Random variables- Probability mass function, distribution and density functions-Joint probability distribution and Joint density functions; Marginal, Conditional distribution and Density functions- Mathematical expectation and its properties- Covariance, Moment generating function.

Module:3	**Correlation and Regression**	**4 hours**

Correlation and Regression – Rank Correlation; Partial and Multiple correlation; Multiple regression.

Module:4	**Probability Distributions**	**7 hours**

Binomial distribution; Poisson distributions; Normal distribution; Gamma distribution; Exponential distribution; Weibull distribution.

Module:5	**Hypothesis Testing-I**	**4 hours**

Testing of hypothesis –Types of errors - Critical region, Procedure for testing of hypothesis- Large sample tests- Z test for Single Proportion- Difference of Proportion- Mean and difference of means.

Module:6	**Hypothesis Testing-II**	**9 hours**

Small sample tests- Student's t-test, F-test- chi-square test- goodness of fit - independence of attributes- Design of Experiments - Analysis of variance – One way-Two way-Three way classifications - CRD-RBD- LSD.

Module:7	**Reliability**	**5 hours**

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

Reliability - Maintainability-Preventive and repair maintenance- Availability.		
Module:8	**Contemporary Issues**	**2 hours**
	Total lecture hours:	**45 hours**

Text Book:

1. R. E. Walpole, R. H. Myers, S. L. Mayers, K. Ye, Probability and Statistics for engineers and scientists, 2012, 9th Edition, Pearson Education.

Reference Books

1. Douglas C. Montgomery, George C. Runger, Applied Statistics and Probability for Engineers, 2016, 6th Edition, John Wiley & Sons.
2. E. Balagurusamy, Reliability Engineering, 2017, Tata McGraw Hill, Tenth reprint.
3. J. L. Devore, Probability and Statistics, 2012, 8th Edition, Brooks/Cole, Cengage Learning.
4. R. A. Johnson, Miller Freund's, Probability and Statistics for Engineers, 2011, 8th edition, Prentice Hall India.
5. Bilal M. Ayyub, Richard H. McCuen, Probability, Statistics and Reliability for Engineers and Scientists, 2011, 3rd edition, CRC press.

Mode of Evaluation: Digital Assignments, Continuous Assessment Tests, Quiz, Final Assessment Test.

Recommended by Board of Studies	24-06-2021		
Approved by Academic Council	No. 64	Date	16-12-2021

BMAT202P	Probability and Statistics Lab	L	T	P	C
		0	0	2	1
Pre-requisite	**BMAT101L, BMAT101P**	**Syllabus version**			
		1.0			

Course Objectives:

1. To enable the students for having experimental knowledge of basic concepts of statistics using R programming.
2. To study the relationship of real-time data and decision making through testing methods using R.
3. To make students capable to do experimental research using statistics in various engineering problems.

Course Outcomes:

At the end of the course the student should be able to:

1. Demonstrate R programming for statistical data.
2. Carry out appropriate analysis of statistical methods through experimental techniques using R.

Indicative Experiments		
1.	Introduction: Understanding Data types; importing/exporting data	Total Laboratory hours: 30
2.	Computing Summary Statistics /plotting and visualizing data using Tabulation and Graphical Representations	
3.	Applying correlation and simple linear regression model to real dataset; computing and interpreting the coefficient of determination	
4.	Applying multiple linear regression model to real dataset; computing and interpreting the multiple coefficients of determination	
5.	Fitting the probability distributions: Binomial distribution	
6.	Normal distribution, Poisson distribution	
7.	Testing of hypothesis for one sample mean and proportion from real time problems	
8.	Testing of hypothesis for two sample means and proportion from real time problems	
9.	Applying the t-test for independent and dependent samples	
10.	Applying Chi-square test for goodness of fit test and Contingency test to real dataset	
11.	Performing ANOVA for real dataset for Completely randomized design, Randomized Block design, Latin square Design	

Text Book

1. Statistical analysis with R by Joseph Schmuller, John wiley and sons Inc., New Jersey 2017.

Reference Books:

1. The Book of R: A First course in Programming and Statistics, by Tilman M Davies, William Pollock, 2016.
2. R for Data Science, by Hadley Wickham and Garrett Grolemund, O' Reilly Media Inc., 2017.

Mode of assessment: Continuous assessment, FAT / Oral examination and others

Recommended by Board of Studies	24-06-2021		
Approved by Academic Council	No. 64	Date	16-12-2021

Course Code	Course Title	L	T	P	C
BPHY101L	Engineering Physics	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To explain the dual nature of radiation and matter.
2. To apply Schrödinger's equation to solve finite and infinite potential problems and apply quantum ideas at the nanoscale.
3. To understand the Maxwell's equations for electromagnetic waves and apply the concepts to semiconductors for engineering applications.

Course Outcome

At the end of the course the student will be able to

1. Comprehend the phenomenon of waves and electromagnetic waves.
2. Understand the principles of quantum mechanics.
3. Apply quantum mechanical ideas to subatomic domain.
4. Appreciate the fundamental principles of a laser and its types.
5. Design a typical optical fiber communication system using optoelectronic devices.

Module:1	**Introduction to waves**	**7 hours**
Waves on a string - Wave equation on a string (derivation) - Harmonic waves- reflection and transmission of waves at a boundary (Qualitative) - Standing waves and their eigenfrequencies.		
Module:2	**Electromagnetic waves**	**7 hours**
Physics of divergence - gradient and curl - Qualitative understanding of surface and volume integral - Maxwell Equations (Qualitative) - Displacement current - Electromagnetic wave equation in free space - Plane electromagnetic waves in free space - Hertz's experiment.		
Module:3	**Elements of quantum mechanics**	**6 hours**
Need for Quantum Mechanics: Idea of Quantization (Planck and Einstein) - Compton effect (Qualitative) – de Broglie hypothesis - - Davisson-Germer experiment - Wave function and probability interpretation - Heisenberg uncertainty principle - Schrödinger wave equation (time dependent and time independent).		
Module:4	**Applications of quantum mechanics**	**5 hours**
Eigenvalues and eigenfunction of particle confined in one dimensional box - Basics of nanophysics - Quantum confinement and nanostructures - Tunnel effect (qualitative) and scanning tunneling microscope.		
Module:5	**Lasers**	**6 hours**
Laser characteristics - spatial and temporal coherence - Einstein coefficients and their significance - Population inversion - two, three and four level systems - Pumping schemes - threshold gain coefficient - Components of a laser - He-Ne, Nd:YAG and CO_2 lasers and their engineering applications.		
Module:6	**Propagation of EM waves in optical fibers**	**6 hours**
Introduction to optical fiber communication system - light propagation through fibers - Acceptance angle - Numerical aperture - V-parameter - Types of fibers – Attenuation - Dispersion-intermodal and intramodal. Application of fiber in medicine - Endoscopy.		
Module:7	**Optoelectronic devices**	**6 hours**
Introduction to semiconductors - direct and indirect bandgap – Sources: LED and laser diode, Photodetectors: PN and PIN.		
Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Textbook(s)	
1.	H. D. Young and R. A. Freedman, University Physics with Modern Physics, 2020, 15th Edition, Pearson, USA.
2.	D. K. Mynbaev and Lowell L. Scheiner, Fiber Optic Communication Technology, 2011, 1st Edition, Pearson, USA
Reference Books	
1.	H. J. Pain, The Physics of vibrations and waves, 2013, 6th Edition, Wiley Publications, India.
2.	R. A. Serway, J. W. Jewett, Jr, Physics for Scientists and Engineers with Modern Physics, 2019, 10th Edition, Cengage Learning, USA.
3.	K. Krane, Modern Physics, 2020, 4th Edition, Wiley Edition, India.
4.	M.N.O. Sadiku, Principles of Electromagnetics, 2015, 6th Edition, Oxford University Press, India.
5.	W. Silfvast, Laser Fundamentals, 2012, 2nd Edition, Cambridge University Press, India.
Mode of Evaluation: Written assignment, Quiz, CAT and FAT	

Recommended by Board of Studies	26-06-2021		
Approved by Academic Council	No. 63	Date	23-09-2021

BPHY101P	**Engineering Physics Lab**	**L**	**T**	**P**	**C**
		0	**0**	**2**	**1**
Pre-requisite	**12th or equivalent**	**Syllabus version**			
		1.0			

Course Objectives

To apply theoretical knowledge gained in the theory course and get hands-on experience of the topics.

Course Outcome

At the end of the course the student will be able to

1. Comprehend the dual nature of radiation and matter by means of experiments.
2. Get hands-on experience on the topics of quantum mechanical ideas in the laboratory.
3. Apply low power lasers in optics and optical fiber related experiments.

Indicative Experiments	
1.	To determine the dependence of fundamental frequency with the length and tension of a stretched string using sonometer.
2.	To determine the characteristics of EM waves using Hertz experiment
3.	To determine the wavelength of laser source (He-Ne laser and diode lasers of different wavelengths) using diffraction grating
4.	To demonstrate the wave nature of electron by diffraction through graphite sheet
5.	To determine the Planck's constant using electroluminescence process
6.	To numerically demonstrate the discrete energy levels and the wavefunctions using Schrödinger equation (e.g., particle in a box problem can be given as an assignment)
7.	To determine the refractive index of a prism using spectrometer (angle of prism will be given)
8.	To determine the efficiency of a solar cell
9.	To determine the acceptance angle and numerical aperture of an optical fiber
10.	To demonstrate the phase velocity and group velocity (simulation)
	Total Laboratory Hours **30 hours**

Mode of assessment: Continuous assessment / FAT / Oral examination

Recommended by Board of Studies	26.06.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BSTS101P	Quantitative Skills Practice I	L	T	P	C
		0	0	3	1.5
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. To enhance the logical reasoning skills of the students and help them improve problem-solving abilities
2. To acquire skills required to solve quantitative aptitude problems
3. To boost the verbal ability of the students for academic and professional purposes

Course Outcomes:

1. Exhibit sound knowledge to solve problems of Quantitative Aptitude
2. Demonstrate ability to solve problems of Logical Reasoning
3. Display the ability to tackle questions of Verbal Ability

Module:1	**Logical Reasoning**	**5 hours**

Word group categorization questions
Puzzle type class involving students grouping words into right group orders of logical sense
Cryptarithmetic

Module:2	**Data arrangements and Blood relations**	**6 hours**

Linear Arrangement - Circular Arrangement - Multi-dimensional Arrangement - Blood Relations

Module:3	**Ratio and Proportion**	**6 hours**

Ratio - Proportion - Variation - Simple equations - Problems on Ages - Mixtures and alligations

Module:4	**Percentages, Simple and Compound Interest**	**6 hours**

Percentages as Fractions and Decimals - Percentage Increase / Decrease - Simple Interest - Compound Interest - Relation Between Simple and Compound Interest

Module:5	**Number System**	**6 hours**

Number system- Power cycle - Remainder cycle - Factors, Multiples - HCF and LCM

Module:6	**Essential grammar for Placement**	**7 hours**

- Prepositions
- Adjectives and Adverbs
- Tense
- Speech and Voice
- Idioms and Phrasal Verbs
- Collocations, Gerunds and Infinitives
- Definite and Indefinite Articles
- Omission of Articles
- Prepositions
- Compound Prepositions and Prepositional Phrases
- Interrogatives

Module:7	**Reading Comprehension for Placement**	**3 hours**

Types of questions - Comprehension strategies - Practice exercises

Module:8	**Vocabulary for Placement**	**6 hours**

Exposure to questions related to Synonyms – Antonyms – Analogy - Confusing words - Spelling correctness

	Total Lecture hours:	**45 hours**

Text Book(s)

1. SMART. (2018). *Place Mentor* 1st (Ed.). Chennai: Oxford University Press.
2. Aggarwal R.S. (2017). *Quantitative Aptitude for Competitive Examinations* 3rd (Ed.). New Delhi: S. Chand Publishing.

3.	FACE. (2016). *Aptipedia Aptitude Encyclopedia* 1st (Ed.). New Delhi: Wiley Publications.			
4.	ETHNUS. (2016). *Aptimithra,*1st (Ed.) Bangalore: McGraw-Hill Education Pvt. Ltd.			
Reference Books				
1.	Sharma Arun. (2016). *Quantitative Aptitude*, 7th(Ed.). Noida: McGraw Hill Education Pvt. Ltd.			
Mode of evaluation: CAT, Assessments and FAT (Computer Based Test)				
Recommended by Board of Studies		28.06.2021		
Approved by Academic Council		No. 63	Date	23.09.2021

Course Code	Course Title	L	T	P	C
BSTS201P	Qualitative Skills Practice - I	0	0	3	1.5
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives:

1. To enhance the logical reasoning skills of students and improve problem-solving abilities
2. To strengthen the ability of solving quantitative aptitude problems
3. To enrich the verbal ability of the students for academic purposes

Course Outcomes:

1. Become experts in solving problems of quantitative Aptitude
2. Learn to defend and critique concepts of logical reasoning
3. Integrate and display verbal ability effectively

Module:1	**Lessons on excellence**	**2 hours**

Skill introspection - Skill acquisition - consistent practice

Module:2	**Thinking Skill**	**6 hours**

- Problem Solving
- Critical Thinking
- Lateral Thinking

Rebus puzzles, and word-link builder questions

Module:3	**Logical Reasoning**	**6 hours**

- Coding and Decoding
- Series
- Analogy
- Odd Man Out
- Visual Reasoning

Module:4	**Sudoku puzzles**	**3 hours**

Solving introductory to moderate level sudoku puzzles to boost logical thinking and comfort with numbers

Module:5	**Attention to detail**	**3 hours**

Picture and word driven Qs to develop attention to detail as a skill

Module:6	**Quantitative Aptitude**	**14 hours**

Speed Maths

- Addition and Subtraction of bigger numbers
- Square and square roots
- Cubes and cube roots
- Vedic maths techniques
- Multiplication Shortcuts
- Multiplication of 3 and higher digit numbers
- Simplifications
- Comparing fractions
- Shortcuts to find HCF and LCM
- Divisibility tests shortcuts

Algebra and functions		
Module:7	**Verbal Ability**	**6 hours**
Grammar challenge A practice paper with sentence based and passage-based questions on grammar discussed - Nouns and Pronouns, Verbs, Subject-Verb Agreement, Pronoun-Antecedent Agreement, Punctuations **Verbal reasoning**		
Module:8	**Recruitment Essentials**	**5 hours**
Looking at an engineering career through the prism of an effective resume • Importance of a resume - the footprint of a person's career achievements • Designing an effective resume • An effective resume vs. a poor resume • Skills you must build starting today the requisite? • How does one build skills **Impression Management** Getting it right for the interview: • Grooming, dressing • Body Language and other non-verbal signs • Displaying the right behaviour		
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	SMART. (2018). *Place Mentor* 1st (Ed.). Chennai: Oxford University Press.
2.	Aggarwal R.S. (2017). *Quantitative Aptitude for Competitive Examinations* 3rd (Ed.). New Delhi: S. Chand Publishing.
3.	FACE. (2016). *Aptipedia Aptitude Encyclopedia* 1st (Ed.). New Delhi: Wiley Publications.
4.	ETHNUS. (2016). *Aptimithra,*1st (Ed.) Bangalore: McGraw-Hill Education Pvt.Ltd.
Reference Books	
1.	Sharma Arun. (2016). *Quantitative Aptitude*, 7th(Ed.). Noida: McGraw Hill Education Pvt. Ltd.

Mode of evaluation: CAT, Assessments and FAT (Computer Based Test)

Recommended by Board of Studies	28-06-2021		
Approved by Academic Council	No. 68	Date	19-12-2022

Course Code	Course Title	L	T	P	C
BSTS202P	Qualitative Skills Practice - II	0	0	3	1.5
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives:

1. To apply critical thinking skills to related to their subject matter
2. To demonstrate competency in verbal, quantitative and reasoning aptitude
3. To produce good written skills for effective communication

Course Outcomes:

1. Apply critical thinking skills to problems solving related to their subject matter
2. Demonstrate competency in verbal, quantitative and reasoning aptitude
3. Display good written skills for use in academic and professional scenarios

Module:1	Logical Reasoning	5 hours

- Clocks
- Calendars
- Direction Sense
- Cubes

Practice on advanced problems

Module:2	Data interpretation and Data sufficiency - Advanced	5 hours

- Advanced Data Interpretation and Data Sufficiency questions of CAT level
- Multiple chart problems
- Caselet problems

Module:3	Time and work– Advanced	5 hours

- Work with different efficiencies
- Pipes and cisterns: Multiple pipe problems
- Work equivalence
- Division of wages
- Advanced application problems with complexity in calculating total work

Module:4	Time, Speed and Distance - Advanced	5 hours

- Relative speed
- Advanced Problems based on trains
- Advanced Problems based on boats and streams
- Advanced Problems based on races

Module:5	Profit and loss, Partnerships and averages - Advanced	5 hours

- Partnership
- Averages
- Weighted average
- Advanced problems discussed

Module:6	Number system - Advanced	4 hours

Advanced application problems on Numbers involving HCF, LCM, divisibility tests, remainder and power cycles.

Module:7	**Verbal Ability**	**13hours**

Sentence Correction - Advanced

- Subject-Verb Agreement
- Modifiers
- Parallelism
- Pronoun-Antecedent Agreement
- Verb Time Sequences
- Comparisons
- Prepositions
- Determiners

Quick introduction to 8 types of errors followed by exposure to GMAT level questions

Sentence Completion and Para-jumbles - Advanced

- Pro-active thinking
- Reactive thinking (signpost words, root words, prefix suffix, sentence structure clues)
- Fixed jumbles
- Anchored jumbles

Practice on advanced GRE/ GMAT level questions

Reading Comprehension – Advanced

Exposure to RCs of the level of GRE/ GMAT relating to a wide variety of subjects

Module:8	**Writing skills for Placement**	**3 hours**

Essay writing

- Idea generation for topics
- Best practices
- Practice and feedback

	Total Lecture hours:	**45 hours**

Text Book(s)

1.	SMART. (2018). *Place Mentor* 1st (Ed.). Chennai: Oxford University Press.
2.	Aggarwal R.S. (2017). *Quantitative Aptitude for Competitive Examinations* 3rd (Ed.). New Delhi: S. Chand Publishing.
3.	FACE. (2016). *Aptipedia Aptitude Encyclopedia* 1st (Ed.). New Delhi: Wiley Publications.
4.	ETHNUS. (2016). *Aptimithra,*1st (Ed.) Bangalore: McGraw-Hill Education Pvt. Ltd.

Reference Books

1.	Sharma Arun. (2016). *Quantitative Aptitude*, 7th(Ed.). Noida: McGraw Hill Education Pvt. Ltd.

Mode of evaluation: CAT, Assessments and FAT (Computer Based Test)			
Recommended by Board of Studies	28-06-2021		
Approved by Academic Council	No. 68	Date	19-12-2022

BECE201L	Electronic Materials and Devices	L	T	P	C
		3	0	0	3
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To introduce the students with concepts of electronic materials and their properties
2. To demystify semiconductor device physics and electronics.
3. To equip the students with the tools for solving problems of semiconductor devices and circuits.
4. To familiarize the students with various electronic devices and their circuit applications.

Course Outcome

Students will be able to:

1. Comprehend the basics of electronic materials, crystal structure, electrical and thermal conduction in solids.
2. Draw and analyze the band diagrams of semiconductor devices.
3. Understand and model the carrier transport mechanisms in semiconductors.
4. Design and model the PN- junctions for given specifications.
5. Develop small signal models for BJT and also design BJT amplifiers under different Configurations.
6. Model MOS capacitors, MOSFETs; learn and mitigate the short channel effects and design future technology nodes.

Module:1	**Electrical and Thermal conduction in Solids**	**6 hours**

Crystalline state – Crystalline defects – Single Cyrstal Growth -Czochralski Growth – Amorphous Semiconductor - Classical Theory: Drude Model – Temperature dependence of resistivity – The Hall Effect and Hall Devices – Thermal conduction – Electrical conductivity of non-metals – Skin Effect – Thin metal films.

Module:2	**Semiconductor Fundamentals**	**7 hours**

Introduction to Solids, Crystals, and Electronic materials – Formation of energy bands – Energy band Model – Effective mass - Direct and indirect bandgap – Elemental and compound semiconductors, Intrinsic and extrinsic semiconductors. The density of states, Carrier statistics, Fermi level, Equilibrium carrier concentration, Quasi-equilibrium, and Quasi-Fermi level.

Module:3	**Carrier Transport Mechanism**	**6 hours**

Charge carriers in semiconductors – Drift and Diffusion of carriers – Mobility – Generation, Recombination and injection of carriers – Carrier transport equations – Excess carrier lifetime.

Module:4	**Junction diodes**	**8 hours**

PN Junction – Equilibrium and biased – Contact potential and space charge phenomena, Current – Voltage relationship, Diode capacitances, One-sided PN junction, Avalanche and Zener breakdown, Zener diode, small-signal model of PN junction. Metal-Semiconductor Contact: Schottky diode, current-voltage characteristics, Ohmic contacts. Varactor diode, Tunnel diode, Photo Diode, Solar Cells.

Module:5	**Bipolar Junction Transistor**	**5 hours**

Device structure and physical operation, Current – Voltage relationship – CB, CE, and CC configuration – Nonideal effects – Base width modulation – Ebers-Moll model. Small signal models, Device capacitances – Equivalent circuit model.

Module:6	**Field Effect Transistor**	**7 hours**

JFET, MOS Capacitors: Energy-band diagrams, flat-band, accumulation, depletion, inversion, threshold voltage, Capacitance-Voltage characteristics. MOSFETs: Current-Voltage characteristics, velocity saturation, leakage currents, short channel effects – Vt roll-off and drain-induced barrier lowering, scaling limits, alternative technologies. Equivalent circuit model-second order effects.

Module:7	**Other Electronic Materials**	**4 hours**
Dielectrics, Insulators, Ferroelectric Materials, Supercapacitors, Graphene, Carbon Nanotubes, Superconductors		
Module:8	**Contemporary Topics**	**2 hours**
Guest lecture from industry and R & D organizations		
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	S.O.Kasap, Principles of Electronic Materials and Devices , 2018, 4th Edition, McGraw Hill Education.
Reference Books	
1.	Simon Sze, Ming-Kwei Lee, Semiconductor Devices, Physics and Technology,2012, 3rd Edition, Wiley International Student Version.
2.	Ben G Streetman and Sanjay Kumar Banerjee, Solid State Electronic Devices, 2015, 7th Edition, Pearson.
3.	Adel S. Sedra, Kenneth C. Smith & Arun N. Chandorkar, Microelectronic Circuits: Theory and Applications,2014, 7th Edition, Oxford University Press, New York.
4.	Donald A. Neamen, Semiconductor Physics and Devices, 2017,4th Edition, McGraw Hill.

Mode of Evaluation: CAT / written assignment / Quiz / FAT / Project / Seminar / group discussion / fieldwork (include only those that are relevant to the course. Use ',' to separate the evaluations. Eg. CAT, Quiz and FAT.			
Recommended by Board of Studies	09-11-2021		
Approved by Academic Council	No. 64	Date	16-12-2021

BECE202L	Signals and Systems	L	T	P	C
		2	1	0	3
Pre-requisite	**BMAT102L**	**Syllabus version**			
		1.0			

Course Objectives

1. To understand the basic attributes of signals and systems.
2. To analyse the signals and systems in time and transformed domains such as Fourier, Laplace and Z- transform.
3. To understand the concept of sampling process.

Course Outcome

On studying this course, students will be able to

1. Differentiate between various types of signals and understand the implication of operations on signals.
2. Understand the terms like causal, dynamic, linear, time invariant and stability of systems. Also, students will be able to compute impulse response of both continuous time and discrete time systems.
3. Perform the transformation of CT and DT signals from time domain to frequency domain and understand the concept of distribution of energy as a function of frequency.
4. Convert the CT signals to DT signals and vice versa and understand their consequences.
5. Processing of bandpass signals through bandpass systems.
6. Solve differential and difference equations, with initial conditions, using Laplace and Z transforms respectively.

Module:1	**Continuous Time and Discrete Time signals**	**7 hours**

Signal classification – Types of signals: Unit impulse, unit step, ramp, sign, and exponential signals – Operations on signals – Analogy between vectors and signals –Concept of linearly dependent and independent vectors, Orthogonality – Mean square error – Computation of energy, power, periodicity, Norms and moments of signals, – Distance metrics for signals.

Module:2	**Continuous Time and Discrete Time systems**	**7 hours**

Classification of systems – Linearity, time invariance, stability, Invertibility, Causality and memory systems. Interconnection of systems. Systems defined by differential & difference equations- Impulse and step response of the systems. Transmission of signals through LTI systems - Convolution and Correlation for CT and DT systems

Module:3	**Fourier Series**	**5 hours**

The response of LTI systems to complex exponentials, Fourier series representation of Continuous Time Periodic Signals, Gibb's phenomena, Properties of CTFS, Fourier series representation of Discrete Time Periodic Signals, Properties of DTFS, Power spectral density.

Module:4	**Fourier Transforms**	**6 hours**

Representation of aperiodic continuous signals: The Continuous Time Fourier Transform, The Fourier Transform for Periodic Signals, Properties of CTFT, Systems characterized by linear constant-coefficient Differential Equations.

Representation of aperiodic discrete signals: The Discrete Time Fourier Transform, The Fourier Transform for Periodic Signals, Properties of DTFT, DTFT of systems characterized by linear constant-coefficient Difference Equations. Energy spectral density.

Module:5	**Hilbert Transform and processing of Band Pass signals**	**6 hours**

Magnitude and phase response of the systems, Group delay, Representation of bandpass

signals: In-phase and quadrature phase components, Hilbert transform – Pre and complex envelopes. Processing of bandpass signals through bandpass systems.		
Module:6	**Sampling**	**4 hours**
Impulse train sampling -Zero order hold, Nyquist criteria – Aliasing - Reconstruction – Ideal filtering		
Module:7	**Laplace and Z-Transform**	**8 hours**
Laplace transform: Definition – ROC – Properties – S-plane causality and BIBO stability – Transfer function – Unilateral Laplace transform: Solution of differential equations with initial conditions. Z-transform: Definition - S-plane to Z-plane mapping - ROC – Properties of Z-transform. System analysis – Transfer function - Causality- BIBO stability – Unilateral Z-transform, Solution of. Difference equations with initial conditions.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Alan V.Oppenheim, Alan S.Willsky, with S.Hamid Nawab, "Signals and Systems", Prentice-Hall of India.2nd Edition,2016.
2.	M.J.Roberts, Govind Sharma, "Fundamentals of Signals and Systems", 2nd Edition, Tata McGraw-Hill,2017.
Reference Books	
1.	Simon Haykin, Barry Van Veen, “Signals and Systems”, 2nd edition, Wiley Publications, 2021.
2.	P. Rama Krishna Rao and Shankar Prakriya, “Signals and Systems”, second edition - Mc-Graw Hill, 2017.
3	Simon Haykin, “Communication systems”, 4th edition, Wiley Publications.
4	Lathi BP, “Signals, Systems and Communications”, 2nd Edition, BS Publications 2019.

Mode of assessment: Continuous assessment / FAT / Assignments, Oral examination and others			
Recommended by Board of Studies	09-11-2021		
Approved by Academic Council	No. 64	Date	16-12-2021

BECE203L	Circuit Theory	L	T	P	C
		3	1	0	4
Pre-requisite	**BEEE101L, BEEE101P**	**Syllabus version**			
		1.0			

Course Objectives

1. To prepare the students to analyse the given electrical network using phasors and graph theory.
2. To introduce the students with the basic knowledge of Laplace transform, Fourier Transform and Fourier series and to analyse the network using suitable technique.
3. To prepare the students to analyse the two-port networks, passive filters, and attenuators.

Course Outcome

1. Apply the knowledge of various circuit analysis techniques such as mesh analysis, nodal analysis, and network theorems to investigate the given network.
2. Analyse the resonance and transient response of the first order, second order circuits
3. Able to solve the networks using graphical approach.
4. Design and analyse two-port networks, passive filters and attenuators.
5. Able to analyse the given network by transforming from time domain to S domain.
6. Analyse the given network using Fourier series and transforming from time domain to frequency domain.

Module:1	**Sinusoidal Steady-State Analysis**	**10 hours**

Review of steady state sinusoidal analysis using phasors. Node voltage and Mesh current analysis, special cases. Network theorems: Superposition, Thevenin, Norton and maximum power transfer theorems.

Module:2	**Transient Response of first order, second order circuits and Resonance**	**10 hours**

Time response in inductance (L) and capacitance (C), steady state response of circuits with RLC components. Response (forced & natural) of first order circuits (RL & RC): series, parallel, source free, complex circuits with more than one resistance, power sources and switches. Response of second order circuit (RLC): series, parallel and complex circuits. Series and parallel resonance condition.

Module:3	**Network Graphs**	**6 hours**

Definition of terms. Matrices associated with graphs: incidence, reduced incidence, fundamental cut-set and fundamental tie-set.

Module:4	**Two-Port Networks**	**8 hours**

Significance and applications of one port and two port networks. Two port network analysis using Admittance (Y) parameters, Impedance (Z) parameters and Hybrid (h) parameters. Interconnection of Two port networks

Module:5	**Filters, Attenuators and equalizers**	**8 hours**

Concept of filtering. Filter types: Low-pass, High-pass, Band-pass and Band-stop and their characteristics. Design of attenuators: T, π, Lattice and Bridged-T types, Equalizers.

Module:6	**Circuit Analysis in the S domain**	**8 hours**

Introduction to Laplace transform (LT), poles, zeros and transfer functions. Analysis of first and second order circuits subjected to periodic and aperiodic excitations using Laplace transforms.

Module:7	**Application of Fourier series and Fourier transforms in Circuit Analysis**	**8 hours**

Trigonometric Fourier series, Symmetry conditions, Applications in circuit solving, Fourier transforms. Properties, Applications in circuit solving, Comparisons of Fourier and Laplace transforms.

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**60 hours**

Text Book(s)	
1.	Charles K. Alexander, Matthew N. O. Sadiku, "Fundamentals of Electric Circuits," 2020, Seventh Edition, McGraw Hill Higher Education.
Reference Books	
1.	W.H.Hayt, J.E.Kemmerly & S.M.Durbin, "Engineering Circuit Analysis", 2019, Ninth Edition, McGraw Hill Higher Education.
2.	Allan R. Hambley, "Electrical Engineering – Principles & applications", 2016, Sixth Edition, Pearson Education, Noida, India.

Mode of Evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT)

Recommended by Board of Studies	09-11-2021		
Approved by Academic Council	No. 64	Date	16-12-2021

Course Code	Course Title	L	T	P	C
BECE102L	Digital Systems Design	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

1. Provide an understanding of Boolean algebra and logic functions.
2. Develop the knowledge of combinational and sequential logic circuit design.
3. Design and model the data path circuits for digital systems.
4. Establish a strong understanding of programmable logic.
5. Enable the student to design and model the logic circuits using Verilog HDL.

Course Outcome

At the end of the course the student will be able to

1. Optimize the logic functions using and Boolean principles and K-map.
2. Model the Combinational and Sequential logic circuits using Verilog HDL.
3. Design the various combinational logic circuits and data path circuits.
4. Analyze and apply the design aspects of sequential logic circuits.
5. Analyze and apply the design aspects of Finite state machines.
6. Examine the basic architectures of programmable logic devices.

Module:1	Digital Logic	8 hours

Boolean Algebra: Basic definitions, Axiomatic definition of Boolean Algebra, Basic Theorems and Properties of Boolean Algebra, Boolean Functions, Canonical and Standard Forms, Simplification of Boolean functions. Gate-Level Minimization: The Map Method (K-map up to 4 variable), Product of Sums and Sum of Products Simplification, NAND and NOR Implementation. Logic Families: Digital Logic Gates, TTL and CMOS logic families.

Module:2	Verilog HDL	5 hours

Lexical Conventions, Ports and Modules, Operators, Dataflow Modelling, Gate Level Modelling, Behavioural Modeling, Test Bench.

Module:3	Design of Combinational Logic Circuits	8 hours

Design Procedure, Half Adder, Full Adder, Half Subtractor, Full Subtractor, Decoders, Encoders, Multiplexers, De-multiplexers, Parity generator and checker, Applications of Decoder, Multiplexer and De-multiplexer. Modeling of Combinational logic circuits using Verilog HDL.

Module:4	Design of data path circuits	6 hours

N-bit Parallel Adder/Subtractor, Carry Look Ahead Adder, Unsigned Array Multiplier, Booth Multiplier, 4-Bit Magnitude comparator. Modeling of data path circuits using Verilog HDL.

Module:5	Design of Sequential Logic Circuits	8 hours

Latches, Flip-Flops - SR, D, JK & T, Buffer Registers, Shift Registers - SISO, SIPO, PISO, PIPO, Design of synchronous sequential circuits: state table and state diagrams, Design of counters: Modulo-n, Johnson, Ring, Up/Down, Asynchronous counter. Modeling of sequential logic circuits using Verilog HDL.

Module:6	Design of FSM	4 hours

Finite state Machine(FSM):Mealy FSM and Moore FSM , Design Example : Sequence detection, Modeling of FSM using Verilog HDL.

Module:7	Programmable Logic Devices	4 hours

Types of Programmable Logic Devices: PLA, PAL, CPLD, FPGA Generic Architecture.

Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Textbook(s)	
1.	M. Morris Mano and Michael D. Ciletti, Digital Design: With an Introduction to the Verilog HDL and System Verilog, 2018, 6th Edition, Pearson Pvt. Ltd.
Reference Books	
1.	Ming-Bo Lin, Digital Systems Design and Practice: Using Verilog HDL and FPGAs, 2015, 2nd Edition, Create Space Independent Publishing Platform.
2.	Samir Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, 2009, 2nd edition, Prentice Hall of India Pvt. Ltd.
3.	Stephen Brown and ZvonkoVranesic, Fundamentals of Digital Logic with Verilog Design, 2013, 3rd Edition, McGraw-Hill Higher Education.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE102P	Digital Systems Design Lab	0	0	2	1
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objective

- To apply theoretical knowledge gained in the theory course and get hands-on experience of the topics.

Course Outcome

At the end of the course the student will be able to

1. Design, simulate and synthesize combinational logic circuits, data path circuits and sequential logic circuits using Verilog HDL.
2. Design and implement FSM on FPGA.
3. Design and implement small digital systems on FPGA.

Indicative Experiments

1.	Characteristics of Digital ICs, Realization of Boolean expressions	**2 hours**
2.	Design and Verilog modeling of Combinational Logic circuits	**4 hours**
3.	Design and Verilog modeling of various data path elements - Adders	**2 hours**
4.	Design and Verilog modeling of various data path elements - Multipliers	**2 hours**
5.	Implementation of combinational circuits – (FPGA / Trainer Kit)	**2 hours**
6.	Implementation of data path circuit - (FPGA / Trainer Kit)	**2 hours**
7.	Design and Verilog modeling of simple sequential circuits like Counters and Shift registers	**2 hours**
8.	Design and Verilog modeling of complex sequential circuits	**2 hours**
9.	Implementation of Sequential circuits - (FPGA / Trainer Kit)	**2 hours**
10.	Design and Verilog modeling of FSM based design – Serial Adder	**2 hours**
11.	Design and Verilog modeling of FSM based design – Traffic Light Controller / Vending Machine	**4 hours**
12.	Design of ALU	**4 hours**
	Total Laboratory Hours	**30 hours**

Mode of Assessment: Continuous Assessment and Final Assessment Test

Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE204L	Microprocessors and Microcontrollers	3	0	0	3
Pre-requisite	BECE102L	Syllabus version			
		1.0			

Course Objectives:

1. To acquaint students with architectures of Intel microprocessors, microcontroller and ARM processors.
2. To familiarize the students with assembly language programming in 8051 microcontroller and ARM processor.
3. To interface peripherals and I/O devices with the 8051 microcontroller.

Course Outcome:

At the end of the course, the student should be able to

1. Comprehend the various microprocessors including Intel Pentium Processors
2. Infer the architecture and Programming of Intel 8086 Microprocessor.
3. Comprehend the architectures and programming of 8051 microcontroller.
4. Deploy the implementation of various peripherals such as general purpose input/ output, timers, serial communication, LCD, keypad and ADC with 8051 microcontroller
5. Infer the architecture of ARM Processor
6. Develop the simple application using ARM processor.

Module:1	Overview of Microprocessors	3 hours

Introduction to Microprocessors, 8-bit/16-bit Microprocessor, Overview of Intel Pentium, I (i3, i5, i7) Series Processor.

Module:2	Microprocessor Architecture and Interfacing: Intel x86	8 hours

16-bit Microprocessor: 8086 - Architecture and Addressing modes, Memory Segmentation, Instruction Set, Assembly Language Processing, Programming with DOS and BIOS function calls, minimum and maximum mode configuration, Programmable Peripheral Interface (8255), Programmable Timer Controller (8254), Memory Interface to 8086.

Module:3	Microcontroller Architecture: Intel 8051	7 hours

Microcontroller 8051 - Organization and Architecture, RAM-ROM Organization, Machine Cycle, Instruction set: Addressing modes, Data Processing - Stack, Arithmetic, Logical; Branching – Unconditional and Conditional, Assembly programming.

Module:4	Microcontroller 8051 Peripherals	5 hours

I/O Ports, Timers-Counters, Serial Communication and Interrupts.

Module:5	I/O interfacing with Microcontroller 8051	7 hours

LCD, LED, Keypad, Analog-to-Digital Convertors, Digital-to-Analog Convertors, Sensor with Signal Conditioning Interface.

Module:6	ARM Processor Architecture	5 hours

ARM Design Philosophy; Overview of ARM architecture; States [ARM, Thumb, Jazelle]; Registers, Modes; Conditional Execution; Pipelining; Vector Tables; Exception handling.

Module:7	ARM Instruction Set	8 hours

ARM Instruction- data processing instructions, branch instructions, load store instructions, SWI Instruction, Loading instructions, conditional Execution, Assembly Programming.

Module:8	Contemporary issues	2 hours

	Total Lecture hours:	**45 hours**
Text Book(s)		
1.	A.K. Ray, K.M. Bhurchandi, Advanced Microprocessor and Peripherals, 2012, 2nd Edition, Tata McGraw-Hill, India.	
2.	Mohammad Ali Mazidi, Janice G. Mazidi, Rolin D. McKinlay, The 8051 Microcontroller and Embedded Systems, 2014, 2nd Edition, Pearson, India.	
Reference Books		
1.	Muhammad Ali Mazidi, ARM Assembly Language Programming & Architecture: 1, 2016, 2nd Edition, Microdigitaled.com	
2.	A. Nagoor Kani, 8086 Microprocessors and its Applications, 2017, Second Edition, Tata McGraw-Hill Education Pvt. Ltd., New Delhi, India.	
3.	Joseph Yiu, The Definitive Guide to ARM® Cortex®-M0 and Cortex-M0+ Processors, 2015, 2nd Edition, Elsevier Science & Technology, UK	
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test		
Recommended by Board of Studies	14-05-2022	
Approved by Academic Council	No. 66	Date 16-06-2022

Course Code	Course Title	L	T	P	C
BECE204P	Microprocessors and Microcontrollers Lab	0	0	2	1
Pre-requisite	BECE102L	Syllabus version			
		1.0			

Course Objectives

1. To familiarize the students with assembly language programming using microprocessor and microcontroller.
2. To familiarize the students with Embedded C language programming using microcontroller.
3. To interface peripherals and I/O devices with the microcontroller and microprocessor.

Course Outcome

Student will be able to

1. Showcase the skill, knowledge and ability of programming microcontroller and microprocessor using its instruction set.
2. Expertise with microcontroller and interfaces including general purpose input/ output, timers, serial communication, LCD, keypad and ADC.

Indicative Experiments [Experiments using 8086/8051/ARM]

1	Assembly language programming of Arithmetic/logical operations.	**6 hours**
2	Assembly language programming of memory operations.	**4 hours**
3	Assembly language programming/ Embedded C programming for interfacing the peripherals: General purpose input/ output, timers, serial communication, LCD, keypad and ADC.	**10 hours**
4	Hardware implementation of peripheral interfacing: General purpose input/ output, timers, serial communication, LCD, keypad and ADC.	**10 hours**
	Total Laboratory Hours	**30 hours**

Mode of Assessment: Continuous Assessment and Final Assessment Test			
Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE205L	Engineering Electromagnetics	3	0	0	3
Pre-requisite	BPHY101L, BPHY101P	Syllabus version			
		1.0			

Course Objectives

1. Introduce the basic concepts and properties of Electrostatics & Magnetostatics.
2. Study the propagation of EM wave through time varying Maxwell's equations and to analyze the EM Wave propagation in different conducting and dielectric media.
3. Familiarize the concept of transmission and reflection in various transmission lines and to design different transmission lines and matching circuits using Smith chart.

Course Outcome

At the end of the course, the student will be able to

1. Evaluate and analyse Electric Fields & Electric Potential due to different Charge distributions.
2. Compute and analyze magnetic fields in different materials and media.
3. Analyze the EM wave propagation in conducting as well as in dielectric materials through time varying Maxwell's equations.
4. Illustrate the wave mechanism in different transmission lines at high frequencies using transmission line parameters.
5. Design Impedance matching circuits using Smith chart.
6. Analyze the field components of different waveguides based on various modes of E and H field.

Module:1	Vector Calculus	3 hours

Cartesian, Cylindrical, and Spherical coordinate systems. Divergence, Gradient and Curl.

Module:2	Electrostatics	8 hours

Coulomb's Law, Electric Fields due to Different Charge Distributions, Gauss Law and Applications, Electrostatic Potential, Potential Gradient, Equipotential surfaces, Electric Dipole, Polarization in Dielectrics, Boundary conditions, current density, continuity equation. Laplace and Poisson's equation, Capacitance, Method of Images.

Module:3	Magnetostatics	7 hours

Biot-Savart's Law, Ampere's Circuit Law and Applications, Magnetic Flux Density, Magnetic Scalar and Vector Potentials, Forces due to Magnetic Fields, Magnetic Dipole, Magnetization in materials, Boundary conditions, Inductances and Magnetic Energy.

Module:4	Time Varying Fields	5 hours

Faraday's Law and Lenz law, Maxwell's Equations in Integral and differential form, Wave equation, Uniform plane wave propagation in lossy dielectrics, Lossless Dielectrics, Good Conductors and free space. Polarization, Power and Poynting Vector.

Module:5	Transmission Lines	8 hours

Types, Parameters, Transmission Line Equations, Primary & Secondary Constants, Expressions for Characteristic Impedance, Propagation Constant, Phase velocity, input impedance, Reflection Coefficient, VSWR. Characterization of lossless, low loss and distortionless transmission lines. Significance of short circuit and open circuit lines of length λ/8, λ/4 and λ/2.

Coaxial line, Planar transmission lines –Types, Microstrip Lines: field distribution, design equations, Q factor, losses in microstrip lines.

Module:6	Smith Chart & Matching Circuits	7 hours

Smith Chart configuration and applications: Input impedance, admittance, VSWR, Reflection

Coefficient, return loss, standing wave pattern. Matching Circuit Design- Quarter wave, Impedance Transformer, Single Stub, Double Stub and Lumped element matching.		
Module:7	**Waveguides**	**5 hours**
TEM, TE and TM waves, Parallel plate waveguide, Rectangular waveguide, Characteristics of wave guide- guide wavelength, cut off wave length, cut off frequency, wave impedance, phase constant, phase velocity, group velocity. Circular waveguide and Cavity resonator (Qualitative study)		
Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours:	**45 hours**
Text Book(s)		
1.	William Hayt and John Buck, Engineering Electromagnetics, 2017, 8th Edition, Tata McGraw Hill, New Delhi, India.	
Reference Books		
1.	Mathew O Sadiku, Elements of Electromagnetics, Oxford University press, New York, USA.	
2.	E.C. Jordan and K.G. Balmain, Electromagnetic Waves and Radiating Systems, , PEI, India	
3.	D. M. Pozar, Microwave engineering, 2013, 4th Edition, Wiley & Sons, USA.	
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test		
Recommended by Board of Studies	14-05-2022	
Approved by Academic Council	No. 66	Date 16-06-2022

Course Code	Course Title	L	T	P	C
BECE206L	Analog Circuits	3	0	0	3
Pre-requisite	BECE201L	Syllabus version			
		1.0			

Course Objectives

1. To study the basic principle of BJT and MOSFET amplifiers using suitable biasing techniques and to perform ac analysis.
2. To understand the operation and design of various classes of MOSFET power amplifier circuits.
3. To introduce MOSFET active biasing and design a MOSFET differential amplifier circuit and analyze its frequency response.
4. To study the characteristics of Operational Amplifier and its applications
5. To acquaint and demonstrate the concepts of waveform generators, filter configurations, Timer, data converters, and Voltage regulators.

Course Outcome

At the end of the course the student will be able to

1. Design the BJT and MOSFET amplifier circuits using suitable biasing techniques and analyze their frequency response characteristics.
2. Distinguish among different classes of MOSFET power amplifiers and employ them for various applications.
3. Analyze the different active biasing techniques and MOSFET-based differential amplifiers and their frequency response characteristics.
4. Comprehend the ideal characteristics of OP-AMPs and design the fundamental circuits based on OP-AMPs.
5. Design and analyze different waveform generator circuits using operational amplifiers.
6. Analyze the basic concept of filter circuits, multivibrators using 555 timer, and data converter circuits.

Module:1	DC and AC analysis of amplifiers	9 hours

BJT Circuits: DC biasing, AC coupling and small-signal analysis of amplifiers, Frequency response of a CE amplifier, the three frequency bands, Unity gain frequency, Miller Capacitance, Multistage amplifiers. MOSFET Circuits: DC biasing, AC coupling and small-signal analysis of amplifiers, Frequency response of a CS amplifier, Unity gain frequency, Miller Capacitance, Multistage amplifiers.

Module:2	MOSFET Power Amplifiers	4 hours

Power Amplifiers, Power Transistors, Classes of Amplifiers, Class A Power Amplifiers, Class B, Class AB Push-Pull Complementary Output Stages.

Module:3	MOSFET Active Biasing and Differential Amplifiers	6 hours

Introduction to Current Mirror – Basic, Wilson and Cascode Current Mirror, MOSFET Basic Differential Pair, Large Signal and Small Signal Analysis of Differential Amplifier, Differential Amplifier with active load.

Module:4	Operational Amplifier Characteristics and Applications	7 hours

Operational amplifier, Ideal and Nonideal characteristics of OP-AMP, DC and AC characteristics - Operational amplifier with negative feedback: Voltage Series, Voltage Shunt feedback amplifier - Applications of OP-AMP - summing, scaling, and averaging amplifiers, I/V and V/I converter, Integrator, Differentiator, Instrumentation amplifiers and Precision Rectifiers.

Module:5	**Comparators and Waveform Generators**	**6 hours**
Comparator and its applications - Schmitt trigger - Free-running, One-shot Multivibrators - Barkhausen Criterion - Sinewave generators - Phase-shift and Wein-bridge oscillators - Square, Triangular and Saw-tooth wave function generators.		
Module:6	**Active filters and Data Converters**	**6 hours**
Filter classifications: First and second order Low-pass and High pass filter designs, Band-pass filter, Notch filter. Sample-and-hold circuits, DAC characteristics, D/A conversion techniques, A/D characteristics, A/D conversion techniques.		
Module:7	**Special Function ICs**	**5 hours**
IC 555 timer, Astable and Monostable operations, and applications. IC voltage regulator - LM317.		
Module:8	**Contemporary issues**	**2 hours**
	Total Lecture	**45 hours**

Textbook(s)

1.	Adel S. Sedra, Kenneth C. Smith and Arun N. Chandorkar, Microelectronic Circuits: Theory and Applications, 2014, 7th Edition, Oxford University Press, New York.

Reference Books

1.	J. D. Roy Choudhury, Linear Integrated Circuits, 2018, 5th Edition, New-Age International Publishers, New Delhi.
2.	Donald A Neamen, Microelectronics: Circuit Analysis and Design, 2010, 4th Edition, Mc Graw-Hill.
3.	P. Malvino, D. J. Bates, Electronic Principles, 2017, 7th Edition, Tata Mc Graw-Hill.
4.	R. L. Boylestad and L. Nashelsky, Electronic Devices and Circuit Theory, 2015, 11th Edition, Pearson Education.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test

Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE206P	Analog Circuits Lab	0	0	2	1
Pre-requisite	BECE201L	Syllabus version			
		1.0			

Course Objective

- To apply knowledge gained in the theory course and get hands-on experience of the topics.

Course Outcome

At the end of the course the student will be able to

1. Design and analyse the frequency response of amplifiers and differential amplifiers.
2. Determine the efficiency of different classes of power amplifiers.
3. Design and analyse the waveform generator circuits.

Indicative Experiments

1.	Design of single-stage and multistage amplifiers using BJT and to analyse its frequency response characteristics.	**4 hours**
2.	Design of single-stage and multistage amplifiers using MOSFET and to analyse its frequency response characteristics.	**4 hours**
3.	Design of a Power Amplifier and estimation of its power conversion efficiency	**2 hours**
4.	Design of differential amplifier using MOSFET and determine its CMRR and also perform the frequency response analysis.	**4 hours**
5.	Design of closed-loop amplifiers using Op-amp and perform experimentation to determine voltage gain.	**2 hours**
6.	Design of circuits using op-amp to determine the DC and AC characteristics.	**4 hours**
7.	Design of Instrumentation amplifier for the given specifications.	**2 hours**
8.	Design of Comparator and Schmitt trigger circuits using Op-amp.	**4 hours**
9.	Design of waveform generators and filters using op-amp	**2 hours**
10.	Design of circuits using IC 555 timer for different applications.	**2 hours**
	Total Laboratory Hours	**30 hours**

Mode of Assessment: Continuous Assessment and Final Assessment Test

Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE207L	Random Processes	2	1	0	3
Pre-requisite	BECE202L	Syllabus version			
		1.0			

Course Objectives

1. To familiarize the students with two and multi-random variable theory.
2. To enable the students process the random signals in time and frequency domains.
3. To make the students understand the noise concepts and design a matched filter to increase the Signal to Noise Ratio (SNR).

Course Outcome

The students will be able to

1. Compute the probability density functions for multiple random variables
2. Perform transformation on multiple random variables and complex random variables
3. Interpret the random processes in terms of stationarity, statistical independence, and correlation.
4. Compute the power spectral density of the random signals
5. Interpret the effect of random signals on LTI systems output both in the time and frequency domain.
6. Design the Optimum linear systems for extracting signals in the presence of noise.

Module:1	Continuous and Discrete Multiple Random Variables	6 hours

Introduction to Random Variables – Vector Random Variables- Joint Distribution and its Properties-Joint Density and its Properties-Joint Probability Mass Function – Conditional Distribution and Density-Statistical Independence –Distribution and Density of Function of Random Variables – Central Limit Theorem.

Module:2	Operations on Multiple Random Variables	7 hours

Joint Moments for continuous and discrete random variables – Joint Central Moments – Joint Characteristics Function – Jointly Gaussian Random Variables – Transformations of Multiple Random Variables – Linear Transformation of Gaussian Random Variables – Complex Random Variables.

Module:3	Random Processes – Temporal Characteristics	7 hours

Random Process: Classifications. Stationarity and Independence. Time Averages and Ergodic Random process. Characterizing a Random Process: The Mean, Correlation Functions, Covariance Functions, and their Properties-Different processes: Gaussian Random Process- Poisson Random Process, Weiner Process, and Markov process, and Complex Random Process.

Module:4	Random Processes – Spectral Characteristics	7 hours

Power Density Spectrum and its Properties-Cross PSD and its properties, Relationship between Correlation and Power Spectrum- Power Spectral density of a WSS discrete Time random processes and Sequences. Power Spectrum of Complex Processes.

Module:5	Linear Systems with Random Inputs	5 hours

Linear system Fundamentals-Linear systems with continuous-Time and discrete-Time random inputs. Random Signal Response of Linear Systems-Product Device response to a Random Signal-Spectral Characteristic of System Response. Response of quadratic, half wave, full-wave, and sigmoid detectors to Gaussian signals.

Module:6	Noise and Modelling of Noise Sources	6 hours

Noise Definitions- White noise and colored noise. System Evaluation using Random noise -

Spectral Characteristic of System Response for Noise-Noise Bandwidth – Bandpass – Band limited – Narrow Band Processes. Resistive Noise Sources – Arbitrary Noise Sources – Effective Noise Sources-Noise Temperature-Noise Figure-Incremental Modelling of Noisy Networks- Modelling of Practical Noisy Networks.		
Module:7	**Optimum Linear Systems**	**5 hours**
Signal to Noise Ratio – Mean Square Error- Optimization by Parameter Selection- Matched Filter for Colored Noise- Matched Filter for White Noise-Practical Applications.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	P.Z. Peebles, Probability, Random Variables, and Random Signal Principles, 2017, 4th edition, McGraw Hill, New Delhi, India.
Reference Books	
1.	Papoulis and S.U. Pillai, Probability, Random variables and stochastic processes, 2017, 4th edition, McGraw Hill, New Delhi, India.
2.	Hwei Hsu, Probability, Random variables, Random Processes, 2017, Schaum's outline series, McGraw Hill, New Delhi, India.
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test	

Recommended by Board of Studies	28-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
BECE301L	Digital Signal Processing	3	0	0	3
Pre-requisite	BECE202L	Syllabus version			
		1.0			

Course Objectives

1. To summarize and analyze the concepts of signals, systems in time and frequency domain with the corresponding transformations.
2. To inculcate the design concepts of analog, digital IIR, FIR filters.
3. To instill diverse structures for realizing digital filters.
4. To infuse the novice concepts of Multirate digital signal processing.

Course Outcome

Students will be able to

1. Classify and analyse Signals & Systems along with their time and frequency domain transformations.
2. Simplify Fourier transform computations using swift algorithms.
3. Examine various analog filter design techniques and their digitization.
4. Design FIR and IIR digital filters.
5. Realize digital filters using various system interconnections.
6. Design and formulate Multirate systems.

Module:1	Discrete Signals, Systems and frequency analysis	6 hours

Review of Discrete-Time Signals & Systems and frequency analysis - Z- transform: ROC stability / causality analysis, Frequency domain sampling - Sampling rate conversion - Aperiodic correlation estimation - Cepstrum processing - Band limited discrete time signals.

Module:2	Discrete Fourier Transform, Properties and its applications	6 hours

DFT – Properties - Linear filtering methods - Frequency analysis of signals using DFT - FFT Algorithm - Radix-2 FFT - Sparse FFT - Practical applications.

Module:3	Design of Analog Filters	6 hours

Design techniques for analog filter - Butterworth and Chebyshev approximations - Frequency transformation, Properties - Constant group delay and zero phase filters.

Module:4	Digital transformation of IIR filters	5 hours

IIR filter design: Bilinear transformation, Impulse Invariance - Spectral transformation of Digital filters

Module:5	Design of FIR filters	5 hours

FIR Filter Design: Design characteristics of FIR filters with linear-phase – Frequency response of linear phase FIR filters – Design of FIR filters using windowing techniques: Rectangular, Bartlett Hamming, Hanning, Blackmann, Kaiser - Phase delay, Group delay

Module:6	Realization structures for Discrete-Time Systems	7 hours

Direct, Cascade, Parallel, Lattice and Lattice - Ladder Structures: All pass filter - IIR tapped-cascaded structure. Parallel all pass realization of IIR systems.

Module:7	Multirate digital signal processing	8 hours

Introduction-Implementation of Sampling Rate Conversion: Polyphase Filter Structures - Interchange of Filters and Downsamplers / Upsamplers - Polyphase Structures for Decimation and Interpolation Filters - Structures for Rational Sampling Rate Conversion. Discrete Cosine Transform - Wavelet Transform

Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	John G. Proakis, Dimitris G Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, 2022, 5th Edition, Pearson, USA
Reference Books	
1.	A textbook of Digital Signal Processing, R.S.Kaler, M.Kulkarni, Umesh Gupta, 1st edition, 2019, Dream tech Press, Wiley, India
2.	James McClellan, Ronal Schaeffer, Mark Yoder, Digital Signal Processing first, 2016, 2nd edition, Pearson, USA
3.	Lizhe Tan, Jean Jiang, Digital Signal Processing: Fundamentals and applications, 3rd edition, 2018, Academic Press, USA
4.	S.K.Mitra, Digital Signal Processing, 2013, 4th edition, TMH, New Delhi, India

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test

Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course code	Course Title	L	T	P	C
BECE301P	Digital Signal Processing Lab	0	0	2	1
Pre-requisite	BECE202L	Syllabus version			
		1.0			

Course Objectives

1. To learn the usage of appropriate tools for realizing signal processing modules.

Course Outcome

Students will be able to

1. Generate the various elementary signals using the DSP processor.
2. Implement the sampling and reconstruction process.
3. Design and implement the various systems using the imbibed signal processing concepts.

Indicative Experiments

1.	Introduction to TMS320C6748 processor and code composer studio IDE.	**2 hours**
2.	Generation of elementary signals and illustration of simple signal processing operations on TMS320C6748 processor	**6 hours**
3.	Sampling and Reconstruction of CT signals, DTFT analysis	**6 Hours**
4.	Biomedical / Speech / Audio Signal Analysis	**6 Hours**
5.	Computational analysis using FFT	**3 Hours**
6.	Design of IIR filter	**3 Hours**
7.	Design of FIR filter using windowing techniques	**4 Hours**
	Total Laboratory Hours	**30 Hours**

Mode of Assessment: Continuous Assessment and Final Assessment Test

Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE302L	Control Systems	2	1	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To study the use of transfer function model for the analysis of physical systems and to introduce the components of control system.
2. To provide adequate knowledge in the time response of systems and steady state error analysis along with the understanding of closed-loop and open-loop system analysis in frequency domain.
3. To introduce the design of controllers and compensators for the stability analysis.
4. To introduce state variable representation of physical systems and study the stability analysis in state space approach.

Course Outcomes

Students will be able to

1. Differentiate between open-loop and closed-loop control systems and obtain the transfer function from the mathematical modeling of physical systems.
2. Determine transient and steady state responses of the system with first and second order and also to analyze its error coefficients.
3. Characterize the system stability using R-H criteria and root locus techniques.
4. Analyze the frequency domain response of the control systems.
5. Design the controllers and compensators to estimate the system stability.
6. Analyze the system in state space model through the concept of controllability and observability.

Module:1	Control Systems	3 hours

Basic components of a control system, Applications, Open-loop control system and closed-loop control system, Examples of control system (air conditioner, cruise control, phase-locked loop, etc.), Effects of feedback on overall gain, Types of feedback control system, Linear and non-linear control systems.

Module:2	Mathematical Modeling of Physical Systems	8 hours

Difference and differential equations for LTI SISO and MIMO systems, Mathematical modeling of electrical and mechanical systems, Equivalence between the elements of different types of systems, Transfer function of linear systems, Open-loop transfer function and closed-loop transfer function, Block diagram representation, Block diagram reduction techniques, Signal flow graph using Mason's gain formula.

Module:3	Time Domain Response	6 hours

Transient response and steady state responses, Time domain specifications, Types of test inputs, Response of first order and second order systems, Steady state error, Static error coefficients, Generalized error coefficients.

Module:4	Characterization of Systems	5 hours

Stability – concept and definition, Poles, Zeros, Order and Type of systems; R-H criteria, Root locus analysis.

Module:5	Frequency Domain Response	7 hours

Frequency response – Performance specifications in the frequency domain, Phase margin and gain margin, Bode plot, Polar plot and Nyquist plot, Stability analysis in frequency domain.

Module:6	**Controllers and Compensators Design**	**7 hours**
Controllers – P, PI, PID, Realization of basic compensators, Cascade compensation in time domain and frequency domain, Feedback compensation, Design of lag, lead, lag-lead series compensators.		
Module:7	**State Space Analysis**	**7 hours**
Dynamic system modeling in state space representation: Diagonal canonical form, Jordan canonical form, Solutions of state equations of LTI system, Conversion from state space model to transfer function model and vice versa, Stability analysis in state spaces: Concept of eigenvalues and eigenvectors, State transition matrix using Cayley-Hamilton theorem, Controllability and observability.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Norman S. Nise, Control Systems Engineering, 2019, 8th Edition, John Wiley & Sons, New Jersey, USA
Reference Books	
1.	Farid Golnaraghi and Benjamin C. Kuo, Automatic Control Systems, 2017, 10th Edition, McGraw-Hill Education, India.
2.	I.J. Nagarth and M. Gopal, Control Systems Engineering, 2018, 6th Edition, New Age International Pvt. Ltd., New Delhi, India.
3.	Gene Franklin, J. Powell and Abbas Emami-Naeini, Feedback Control of Dynamic Systems, 2019, 8th Edition, Pearson Education, New Delhi, India.
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test	

Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE303L	VLSI System Design	3	0	0	3
Pre-requisite	BECE102L, BECE102P	Syllabus version			
		1.0			

Course Objectives :

1. To introduce the basic concepts and techniques of modern integrated circuit design.
2. Describe the fundamental principles underlying digital design using CMOS logic and analyze the performance characteristics of these digital circuits.
3. Verify that a design meets its functionality, timing constraints, both manually and through the use of computer-aided design tools.

Course Outcomes :

Students will be able to

1. Analyze the CMOS digital electronics circuits, including logic components and their interconnect using mathematical methods and circuit analysis models
2. Create models of moderately sized CMOS inverters with specified noise margin and propagation delay.
3. Apply CMOS technology-specific layout rules in the placement and routing of transistors and interconnect.
4. Analyse the various logic families and efficient techniques at circuit level for improving power and speed of combinational and sequential logic.
5. Implement the CMOS digital circuits with the specified timing constraints.
6. Design memories with efficient architectures to improve access times, power consumption

Module:1	VLSI Design Overview and MOSFET Theory	8 hours

VLSI Design Flow, Design Hierarchy, Concepts of Regularity, Modularity and Locality, VLSI Design Styles, Design Quality, MOSFET : Device Structure, Electrical behaviour of MOS transistors, Capacitance- Voltage Characteristics and Non-ideal Effects; Effects of scaling on MOSFETs and Interconnects.

Module:2	CMOS Logic Gates	8 hours

CMOS Inverter: DC Transfer Characteristics, Static and Dynamic Behaviour, CMOS Basic Gates, Compound Gates, CMOS Sequential Logic Design – Latches and Flip Flops

Module:3	CMOS Fabrication and Layout	5 hours

CMOS Process Technology N-well, P-well Process, latch up in CMOS technology, Stick Diagram for Boolean Functions using Euler Theorem, Layout Design Rule

Module:4	CMOS Circuits Performance Analysis	5 hours

Delay Estimation, Logical Effort and Transistor Sizing, Performance Estimation - Static & Dynamic Power Dissipation.

Module:5	CMOS Logic Families	8 hours

Pass Transistor Logic, Transmission Gates based Logic Design, pseudo NMOS, Cascode Voltage Switch Logic Dynamic and domino logic, clocked CMOS (C^2MOS) logic and np – CMOS logic.

Module:6	Timing Analysis	4 hours

Introduction to Static timing analysis, Setup Time, Hold Time, calculation of critical path, slack, setup and hold time violations.

Module:7	Semiconductor Memory Design	5 hours

Introduction, Types - Read-Only Memory (ROM) Circuits, Static Read-Write Memory (SRAM) and Dynamic Read-Write Memory (DRAM) Circuits.		
Module:8	**Contemporary issues**	**2 hours**
	Total Lecture Hours:	**45 hours**

Text Book(s)	
1.	Neil H.Weste, Harris, A. Banerjee, CMOS VLSI Design, A circuits and System Perspective, 2015, 4th Edition, Pearson Education, Noida, India.
Reference Book	
1.	Jan M. Rabaey, Anantha Chadrakasan, Borivoje Nikolic, Digital Integrated Circuits: A Design Perspective Paperback, 2016, 2rd Edition, Pearson Education, India.
2.	Sung-Mo Kang, Yusuf Liblebici, Chulwoo Kim, CMOS Digital Integrated Circuits: Analysis and Design, 2019, Revised 4th Edition, Tata Mc Graw Hill, New Delhi, India.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE303P	VLSI System Design Lab	0	0	2	1
Pre-requisite	BECE102L, BECE102P	Syllabus version			
		1.0			

Course Objectives :

- The objective of this laboratory is to apply the theoretical knowledge and explore various design style of CMOS Integrated Circuits (IC) design using the latest EDA tools

Course Outcome :

On completion of this lab course the students will be able to

1. Analyze the performance of CMOS Inverter circuits on the basis of their operation and working.
2. Design the semiconductor memory cell, combinational, sequential and arithmetic circuit using CMOS design rules.
3. Construct layout of CMOS inverter, universal and basic logic gates.

Indicative Experiments

1	Parameter extraction for basic cell structure (NMOS and PMOS devices). • Analysis of MOS with width variation, body effect and estimation of channel length modulation	**2 hours**
2	Design and Analysis of CMOS inverter for arbitrary sizing. • Estimation of Power, Delay, Noise Margin. • Impact of load on performance metrics.	**4 hours**
3	Analysis of CMOS inverter for given specification. • Impact of sizing on Power, Delay, Noise Margin	**2 hours**
4	Analysis of inverter chains using progressive sizing to improve delay performance.	**2 hours**
5	Design and Analysis of Universal gates in static CMOS logic • Effect of input reordering.	**2 hours**
6	Design and Analysis of Boolean Expression (Simple Arithmetic Unit) in static CMOS logic.	**2 hours**
7	Design and Analysis of Pass transistor and Transmission gate based circuits	**4 hours**
8	Design and Analysis of CMOS sequential circuits (Latches and Flip Flops)	**4 hours**
9	Design a CMOS Memory cell (SRAM, DRAM) and verify its operation.	**4 hours**
10	Design Layout of CMOS inverter and perform post-layout analysis, DRC, Layout Vs. Schematic, Monte Carlo analysis, Corner analysis and etc.	**4 hours**
	Total Laboratory Hours	**30 hours**

Mode of Assessment: Continuous Assessment and Final Assessment Test

Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE304L	Analog Communication Systems	3	0	0	3
Pre-requisite	BECE206L, BECE206P	Syllabus version			
		1.0			

Course Objectives:

1. To explore the architectural elements and models used in analog communication systems.
2. To analyse bandwidth, current, power and transmission efficiency of analog modulations.
3. To understand the functionalities of transmitters and receivers.
4. To comprehend the effect of noise in analog communication systems.

Course Outcomes:

Students will be able to

1. List and analyse the key elements of analog communication system.
2. Design the various Amplitude Modulation Schemes and evaluate in terms of its power, bandwidth and transmission Efficiency.
3. Examine the various angle modulation schemes.
4. Infer the working principle of radio transmitters and receivers.
5. Analyse the effect of noise on various analog modulations.
6. Analyse various pulse modulation and multiplexing techniques.

Module:1	Communication Systems	4 hours

Need and importance of communication, Elements of communication system - Types of communication systems, Electromagnetic spectrum used in communication, Concept of bandwidth and power, Need for modulation.

Module:2	Amplitude Modulation (AM)	7 hours

Amplitude modulation – Single- tone and Multi-tone, Mathematical representation of AM signal, Bandwidth, current, power and transmission efficiency of AM. Generation of AM signal – Square law modulator, Switching modulator. AM demodulation – Envelope detector and Square law demodulator.

Module:3	Bandwidth and Power Efficient AM Systems	7 hours

DSB-SC generation – Balanced modulator and Ring modulator. DSB-SC demodulation – Synchronous detection, Effect of phase drift. SSB-SC generation – Filter, Phase shift and Third method. SSB-SC demodulation - Synchronous detection. VSB generation and demodulation. Power, bandwidth and transmission efficiency of DSB-SC, SSB-SC and VSB.

Module:4	Angle Modulation	10 hours

Principles of Frequency Modulation (FM) and Phase Modulation (PM) – Relation between FM and PM, Frequency deviation and bandwidth of FM, Narrow band and Wide band FM, Bessel functions and Carson's rule. FM generation and detection. Comparison of amplitude and angle modulation.

Module:5	Transmitters and Receivers	5 hours

Radio transmitter - Classification of transmitters - Low level and High level AM Transmitters, FM Transmitter. Radio receiver - Receiver characteristics, Tuned Radio Frequency (TRF) Receiver, Superheterodyne receiver (AM and FM), Choice of IF and oscillator frequencies, Tracking and Alignment – AGC, AFC. Pre-emphasis and De-emphasis.

Module:6	Noise in Communication Systems	6 hours

Noise and its types- Noise voltage and power, Signal-to-Noise Ratio (SNR), Noise figure, Noise temperature. Figure of Merit in DSB-SC, SSB-SC, AM and FM receivers.

Module:7	**Pulse Modulation Systems**	**4 hours**
Sampling theorem - Types of Sampling. Pulse modulation schemes – generation and detection PAM, PPM and PWM, Conversion of PWM to PPM. Multiplexing Techniques – FDM and TDM.		
Module:8	**Contemporary Issues**	**2 hours**
	Total lecture hours:	**45 hours**

Text Books	
1.	George Kennedy, Bernard Davis, Electronic Communication Systems, 2017, 6th Edition, Mc Graw Hill Education, New Delhi, India.
Reference Books	
1.	Simon Haykin, Communication Systems, 2019, 5th Edition, Wiley, India.
2	P. Ramakrishna Rao, Analog Communication, 2017, Tata McGraw Hill Education Pvt Ltd., India.
3	Herbert Taub and Donald Schilling, Principles of Communication Systems, 2017, 4th Edition, Mc Graw Hill Education, India.
4	HweiKsu and Debjani Mitra, Analog and Digital Communication, 2017, 3rd Edition, McGraw Hill Education, India.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE304P	**Analog Communication Systems Lab**	**0**	**0**	**2**	**1**
Pre-requisite	**BECE206L, BECE206P**	**Syllabus version**			
		1.0			

Course Objectives:

1. Procedurally troubleshoot, construct and analyse modulators and demodulators in analog communication systems.
2. Examine the effect of modulation index and noise in analog communication systems.
3. Inculcate hands-on experience, by integrating theory into practical experiments.

Course Outcome:

Students will be able to

1. Obtain an insight into the functionalities and validate the performance of analog modulators and demodulators.
2. Determine the noise measures for analog communication systems.
3. Sample an analog signal and implement the multiplexing concepts.

Indicative Experiments		
1.	Design of AM, DSB-SC, SSB-SC modulators and demodulators	**8 Hours**
2.	Design of FM, PM modulators and demodulators	**4 Hours**
3.	Design of Superheterodyne receiver - Mixer, Pre-emphasis and De-emphasis	**4 Hours**
4.	Analyse the noise characteristics of analog communication systems – SNR, Noise voltage, Noise figure and Noise temperature	**4 Hours**
5.	Design of PAM,PPM,PWM modulators and demodulators	**6 Hours**
6.	Implementation of TDM and FDM	**4 Hours**
	Total Laboratory Hours	**30 hours**

Mode of Assessment: Continuous Assessment and Final Assessment Test

Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE305L	Antenna and Microwave Engineering	3	0	0	3
Pre-requisite	BECE205L	Syllabus version			
		1.0			

Course Objectives

1. To introduce and discuss the mechanism for antenna parameters, radiating principles, fundamental characteristics and design concepts of HF, UHF, Microwave antennas and arrays.
2. To design and analyse various passive and active microwave circuits.
3. To familiarize the operational principles of microwave sources and to characterize microwave networks.

Course Outcome

Students will be able to

1. Examine the radiation mechanism of electromagnetic fields and identify the various antenna parameters.
2. Apply the design criteria to Linear, HF, UHF, microwave antenna and arrays.
3. Comprehend the performance of different microwave sources and ferrite devices.
4. Design and analyze the passive components at microwave frequencies.
5. Design and analyze the various passive circuits at microwave frequencies.
6. Infer the importance of high frequency transistors to design microwave amplifiers.

Module:1	EM Radiation and Antenna Parameters	8 hours

Radiation mechanism - single wire, two wire and current distribution, Hertzian dipole, Dipole and monopole - Radiation pattern, beam width, field regions, radiation power density, radiation intensity, directivity and gain, bandwidth, polarization, input impedance, efficiency, antenna effective length and area, antenna temperature. Friis transmission equation, Radar range equation.

Module:2	Linear and Planar Arrays	6 hours

Two element array, N-element linear array - broadside array, End fire array - Directivity, radiation pattern, pattern multiplication. Non-uniform excitation - Binomial, Chebyshev distribution, Arrays: Planar array, circular array, Phased Array antenna (Qualitative study).

Module:3	HF, UHF and Microwave Antennas	7 hours

Wire Antennas - long wire, loop antenna - helical antenna. Yagi-Uda antenna, Frequency independent antennas - spiral and log periodic antenna - Aperture antennas – Horn antenna, Parabolic reflector antenna - Microstrip antenna.

Module:4	Microwave Sources	5 hours

Microwave frequencies and applications, Microwave Tubes: TWT, Klystron amplifier, Reflex Klystron & Magnetron. Semiconductor Devices: Gunn diode, Tunnel diode, IMPATT – TRAPATT - BARITT diodes, PIN Diode.

Module:5	Microwave Passive components	6 hours

Microwave Networks - ABCD, 'S' parameter and its properties. E-Plane Tee, H-Plane Tee, Magic Tee and Multi-hole directional coupler. Principle of Faraday rotation, isolator, circulator and phase shifter.

Module:6	Microwave Passive circuits	7 hours

T junction and resistive power divider, Wilkinson power divider, branch line coupler (equal & unequal), Rat Race Coupler, Filter design: Low pass filter (Butterworth and Chebyshev) - Richards transformation and stepped impedance methods.

Module:7	**Microwave Active Circuits**	**4 hours**
Microwave transistors, Microwave amplifiers: Two port power gains, stability of the amplifier, Microwave oscillators.		
Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	C.A. Balanis, Antenna Theory - Analysis and Design, 2016, 4th Edition, Wiley& Sons, New York, USA.
2.	D. M. Pozar, Microwave engineering, 2013, 4th Edition, Wiley & Sons, USA.
Reference Books	
1.	R Ludwig, Gene Bogdanov, RF Circuit design: Theory and applications, 2013, 2nd Edition, Pearson India.
2.	John D Krauss, Antennas for all Applications, 2008, 4th Edition, Tata McGraw Hill, India.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE305P	Antenna and Microwave Engineering Lab	0	0	2	1
Pre-requisite	BECE205L	Syllabus version			
		1.0			

Course Objectives

1. To apply the theoretical knowledge and explore the designing principles of various antennas and microwave devices.
2. To design the various microwave antenna and devices using a suitable design tools.

Course Outcome

Students will be able to

1. Measure the various parameters and comprehend the radiation pattern of wired antennas.
2. Measure the performance of microwave passive devices using test bench setup and also simulate and analyze microwave passive and active circuits.
3. Design the microwave circuits to suit the needs of industry.

Indicative Experiments		
Hardware Experiments:		
1.	Measurement of antenna input impedance	**2 hours**
2.	Measurement of antenna radiation pattern	**2 hours**
3.	Measurement of S-parameters for E-plane, H-plane and Magic Tee	**4 hours**
4.	Measurement of S-parameters for Directional Coupler	**2 hours**
5.	Measurement of S-parameters for Isolator and Circulator	**2 hours**
6.	Measurement of S-parameters of MIC devices	**4 hours**
Experiments using Simulation tools:		
7.	Design of Wilkinson power divider	**2 hours**
8.	Design of branch line and Rat race coupler	**2 hours**
9.	Design of low pass filters: Richards and Stepped impedance method	**2 hours**
10.	Design of matching circuits using quarter wave & single stub.	**4 hours**
11.	Design of dipole antenna	**2 hours**
12	Design of Rectangular patch antenna	**2 hours**
	Total Laboratory Hours	**30 hours**

Mode of Assessment: Continuous Assessment and Final Assessment Test			
Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE306L	Digital Communication Systems	3	0	0	3
Pre-requisite	BECE206L, BECE206P	Syllabus version			
		1.0			

Course Objectives:

1. To understand the transmitter and receiver blocks of various waveform coding techniques.
2. To analyze various line coding techniques in time and frequency domains.
3. To identify the role of baseband, bandpass formats and information theory for effective transmission of signals, combat ISI and to increase the reliability of transmission.
4. To understand the principles and importance of spread spectrum and multiple access in the context of communication.

Course Outcomes:

Students will be able to

1. Comprehend the sampling and quantization process to recover the original signal
2. Analyse the performance of various waveform and Line coding techniques.
3. Design the various baseband pulses for ISI free transmission over finite bandwidth channels.
4. Examine the BER and bandwidth efficiency of the Bandpass modulation techniques.
5. Analyse the digital communication system with spread spectrum modulation.
6. Infer the elements of information theory.

Module:1	Sampling Process	4 hours

Block diagram of a digital communication system, bandwidth of signals. Sampling theorem - quadrature sampling of bandpass signals, Reconstruction of a message from its samples, Practical aspects of sampling and signal recovery.

Module:2	Waveform Coding Techniques	6 hours

Pulse Code Modulation (PCM) - Uniform quantization, Quantization noise, Signal-to-Noise Ratio, Robust quantization. Differential pulse code modulation (DPCM), Delta Modulation (DM) - Quantization noise in DM, Adaptive Delta Modulation.

Module:3	Line Codes	6 hours

Representation of line codes – Unipolar, Polar, Bipolar using NRZ and RZ, Manchester, Polar Quaternary codes, Differential encoding, Properties and applications of line codes – Power spectral density of line codes.

Module:4	Baseband System	5 hours

Baseband data transmission of binary data - Inter Symbol Interference (ISI), Nyquist criterion for zero ISI, Raised cosine filtering, correlative coding (duo binary and modified duo binary coding), eye pattern – Equalization.

Module:5	Bandpass system	12 hours

Gram-Schmidt Orthogonalization Procedure. Correlation and Matched filter receiver. Coherent modulation techniques - BASK, BPSK, BFSK, QPSK, MSK, Higher-order PSK and QAM, BER and Bandwidth efficiency analysis. Non-coherent modulation techniques – BASK, BFSK, DPSK.

Module:6	Spread Spectrum and Multiple Access Techniques	5 hours

Principles of spread spectrum - Generation of PN sequence and its properties, Direct Sequence Spread Spectrum (DSSS), Processing gain, Probability of error, Anti-jam characteristics, Frequency- Hop Spread Spectrum (FHSS). Multiple access techniques - TDMA, FDMA, CDMA, SDMA.

Module:7	**Introduction to Information Theory**	**5 hours**
Entropy, Mutual information and channel capacity theorem. Fundamentals of error correction - Hamming codes.		
Module:8	**Contemporary issues**	**2 hours**
	Total lecture hours:	**45 hours**

Text Book(s)	
1.	Simon Haykin, Digital Communications, 2017, 1st Edition, John Wiley, India.
Reference Books	
1.	John G. Proakis, Masoud Salehi, Digital Communication, 2018, 5th Edition (Indian edition), Mc Graw Hill Education, India.
2.	Bernard Sklar and Fredric J. Harris, Digital Communications: Fundamentals and Applications, 2020, 3rd Edition, Pearson , UK.
3.	B P Lathi, Zhi Ding, Modern Digital And Analog Communication Systems, 2017, 4th Edition, Oxford university Press, India.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE306P	**Digital Communication Systems Lab**	**0**	**0**	**2**	**1**
Pre-requisite	**BECE206L, BECE206P**	**Syllabus version**			
		1.0			

Course Objectives

1. To implement various waveform coding techniques.
2. To analyze various baseband and bandpass signals for effective communication.
3. To understand the principles and importance of multiple access techniques in the context of communication.

Course Outcome

Students will be able to

1. Construct and analyse various waveform coding techniques.
2. Design the circuits for band pass modulators and evaluate their performance.
3. Implement spread spectrum techniques for multiple access communication.

Indicative Experiments		
1.	Generation and reconstruction of PCM, DPCM and DM	**4 Hours**
2	Generation of baseband signals using various line coding formats for the given binary sequence	**4 Hours**
3.	Generation and detection of bandpass modulation techniques	**12 Hours**
4.	BER analysis of bandpass modulation techniques	**2 Hours**
5	Generation of PN sequence and verification of its properties	**4 Hours**
6.	Implementation of multiple access schemes	**4 Hours**
	Total Laboratory Hours	**30 hours**

Mode of Assessment: Continuous Assessment and Final Assessment Test

Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE307L	Wireless and Mobile Communications	2	0	0	2
Pre-requisite	BECE306L, BECE306P	Syllabus version			
		1.0			

Course Objectives:

1. To familiarize the concepts of wireless communication.
2. To teach students the fundamentals of multipath fading and propagation models.
3. To acquaint students with different generations of mobile networks.
4. To describe the diversity and MIMO schemes as applied in wireless communication.

Course Outcome:

The students will be able to

1. Infer the wireless channel using path loss models and interpret the impact of multipath channel parameters.
2. Examine the functions and services of cellular networks.
3. Demonstrate the principles of multicarrier modulation.
4. Select a suitable diversity technique to combat the multipath fading effects.
5. Identify suitable MIMO techniques to enhance the spectrum efficiency.
6. Describe the features of next generation wireless technologies.

Module:1	Mobile Radio Propagation: Large Scale Fading	6 hours

Overview of Wireless Communication, Cellular concept – Frequency reuse – Channel assignment strategies – Handoff strategies – Interference and system capacity – Trunking and grade of service – Improving coverage and capacity in cellular system. Propagation mechanisms, Free space model, Two ray model, Outdoor and indoor propagation models, Link budget design.

Module:2	Mobile Radio Propagation : Small Scale Fading	4 hours

Small scale multipath propagation, Parameters of multipath channels, Types of small scale fading, Rayleigh and Rician fading.

Module:3	Wireless Systems and Standards	3 hours

AMPS,GSM, GPRS, EDGE, UMTS, LTE, LTE-A.

Module:4	OFDM Technology	3 hours

Introduction and Challenges in Multicarrier Systems, OFDM System Model - IFFT/ FFT Transceiver Mathematical Model - Cyclic Prefix, PAPR and reduction techniques - SNR and BER performance - ICI-SC-FDMA.

Module:5	Diversity Techniques	4 hours

Multiple Antenna Wireless Systems-System Model, Types of Diversity: Antenna, Frequency, Time; Deep Fade Analysis with Diversity, Optimal Receiver Combining, MRC, EGC, Diversity Order.

Module:6	MIMO Technology	5 hours

MIMO System Model – Zero Forcing and Minimum Mean Square Error receivers - Singular Value Decomposition - Channel Capacity - Optimal Water filling Power Allocation - Beam forming - Spatial Multiplexing, BLAST Architectures, Distributed MIMO.

Module:7	Next Generation Wireless Communication	3 hours

5G Wireless Technologies - NR Standard, filter bank multicarrier, Non-orthogonal multiple access, D2D, small cells, mmWave, Index Modulation - 6G Key enablers - Reconfigurable

intelligent surfaces.			
Module:8	**Contemporary issues**		**2 hours**
	Total Lecture hours:		**30 hours**
Text Book(s)			
1.	Rappaport, T.S., Wireless Communications: Principles and Practice, 2018, (Reprint), Pearson Education, Noida, India.		
Reference Books			
1.	Andrea Goldsmith, Wireless Communications, 2020, 2nd Edition, Cambridge University Press		
2.	Aditya K. Jagannatham," Principles of Modern Wireless Communications Systems", 2015, McGraw Hill Education		
3.	T L Singal, Wireless Communications, 2014, (Reprint), Tata McGraw Hill Education, 1st edition, New Delhi, India.		
4.	Keith Q T Zhang, Wireless Communications: Principles, Theory and Methodology, 2016, 1st edition, John Wiley & Sons, West Sussex, UK.		
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE307P	Wireless and Mobile Communications Lab	0	0	2	1
Pre-requisite	BECE306L, BECE306P	Syllabus version			
		1.0			

Course Objectives

1. To analyse the fundamentals of multipath fading and propagation models.
2. To understand the principles of multicarrier modulation.
3. To demonstrate the diversity techniques and MIMO Technology.

Course Outcome

Students will be able to

1. Examine and estimate wireless channel using path loss models.
2. Demonstrate the principles of multicarrier modulation.
3. Implement the diversity techniques and MIMO concept in different wireless applications.

Indicative Experiments

1.	Study how call blocking probability varies as the load on a GSM network is continuously increased using Network Simulator	**4 Hours**
2.	To study the effect of various fading channels such as Rayleigh, Ricean and various noise channel such as AWGN and Laplacian noise	**4 Hours**
3.	Simulate to compute the pathloss of urban, suburban and rural environment for LTE/WiMAX/WLAN system using free space, Ericsson, COST 231, ECC, Hata and SUI model	**4 Hours**
4.	Testing and validating principles of Pathloss in Mobile Radio Propagation through Smartphone and CRFO	**2 Hours**
5.	Throughput analysis of LTE network with respect to varying distance between the ENB and UE (User Equipment)	**2 Hours**
6	Write a program to analyse the Bit Error Rate (BER) performance of OFDM using BPSK, QPSK and QAM modulation schemes.	**4 Hours**
7.	Write a program to analyse the following techniques to reduce the PAPR in OFDM. (i)Selective Mapping (SLM) technique (ii) Partial Transmit (PTM) Technique. (iii) Windowing Technique.	**2 Hours**
8.	Comparison of MRC and EGC schemes with SISO fading	**2 Hours**
9.	Comparison of ZF and MMSE MIMO receivers	**4 Hours**
10	HF Radio Channel Simulation using a real-time radio simulator	**2 Hours**
	Total Laboratory Hours	**30 hours**

Mode of Assessment: Continuous Assessment and Final Assessment Test

Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE308L	Optical Fiber Communications	2	0	0	2
Pre-requisite	BECE306L, BECE306P	Syllabus version			
		1.0			

Course Objectives

1. To understand the principles of optical fibers and their signal degradation.
2. To familiarize with the fundamentals of optical sources and detectors used in communications.
3. To learn WDM techniques and its components in contemporary optical communication systems.

Course Outcomes

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

1. List the fundamental optical laws, structures and waveguides.
2. Comprehend the various signal degradation in the fiber optical communication.
3. Design the optical transmitters and receivers and evaluate their performances.
4. Estimate the system requirements for point to point communication.
5. Examine the significance of WDM techniques and their applications.
6. Comprehend and analyse the performance of the various optical amplifiers.

Module:1	Optical Fiber: Structures, Waveguides	3 hours

Key elements of optical fiber system-Ray optics, Mode theory, Geometrical-Optics Description, Fiber Types - specialty fibers.

Module:2	Signal Degradation	5 hours

Attenuation-Absorption, Scattering, Bending losses, Dispersion-Material, Waveguide Dispersion, Polarization Mode Dispersion, Intermodal dispersion, Mode Transit time, Dispersion-Induced Limitations, Nonlinear Optical Effects- SRS, SBS, SPM, CPM, FWM.

Module:3	Optical Transmitters	4 hours

Sources: LED-Structures-Quantum Efficiency, Power and Modulation Bandwidth- LASER-DFB, DBR, VCSEL, Quantum Efficiency, Modulators - Direct and external modulators, Transmitter Design.

Module:4	Optical Receivers	5 hours

Photodetector-PIN, APD, Receiver Design, Receiver Noise-CNR&SNR), Receiver Sensitivity, Quantum limit, Sensitivity Degradation, Receiver Performance-Probability of error, Bit Error rate, Eye-Diagram.

Module:5	Digital links and Measurements	4 hours

Digital links: Point-to-Point Links-System Consideration-Link power budget-Rise time budget, System performance- Attenuation, Dispersion measurements-OTDR.

Module:6	WDM Concepts and Components	5 hours

Overview of WDM, Fiber Coupler-Wave guide coupler-Star couplers, Isolators and Circulators - Fiber Bragg Grating, Filters, Multiplexers, WDM System Performance Issues-Compensation techniques.

Module:7	Optical Amplifiers	2 hours

Semiconductor Optical Amplifiers, Raman Amplifiers, Erbium-Doped Fiber Amplifiers.

Module:8	Contemporary Issues	2 hours

	Total Lecture hours:	**30 hours**
Text Book(s)		
1.	Gerd Keiser, Optical Fiber Communications, 2017, 5th Edition, McGraw Hill Education, India.	
Reference Books		
1.	Conway, E., Optical Fiber Communications Principles and Practice, 2018, 1st Edition, ED-TECH Press, United Kingdom.	
2.	Singal, T. L. Optical Fiber Communications: Principles and Applications, 2017, Cambridge University Press, India.	
3.	Keiser, G., Fiber Optic Communications, 2021, 1st Edition, Springer, Singapore	
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test		
Recommended by Board of Studies	14-05-2022	
Approved by Academic Council	No. 66	Date 16-06-2022

Course Code	Course Title	L	T	P	C
BECE308P	Optical Fiber Communications Lab	0	0	2	1
Pre-requisite	BECE306L, BECE306P	Syllabus version			
		1.0			

Course Objectives

1. To design the optical communication system and study the signal degradation.
2. To familiarize wavelength division multiplexing techniques and associate components.
3. To estimate the link power budget and rise time budget.

Course Outcome

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

1. Establish the optical link and estimate the design parameters.
2. Analyse the optical amplifiers and evaluate their characteristics.
3. Design and analyse the WDM techniques and components.

Indicative Experiments

1.	Design of optical transmission link to analyse the BER performance for different line coding techniques, modulation based on wavelength and length of the fiber.	**6 hours**
2.	Design and analysis of gain, noise figure and saturation of optical amplifier – EDFA, SOA.	**4 hours**
3.	Performance analysis of wavelength division multiplexing (WDM) techniques and passive optical components (Optical coupler, Isolator, Circulator, FBG & OADM)	**8 hours**
4.	Analyse the different dispersion compensation techniques and fiber non-linear effects.	**8 hours**
5.	Design of point-to-point optical system, estimate the power and rise-time budget and detect the fiber faults using OTDR.	**4 hours**
	Total Laboratory Hours	**30 hours**

Mode of Assessment: Continuous Assessment and Final Assessment Test

Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE401L	Computer Communications and Networks	3	0	0	3
Pre-requisite	BECE306L, BECE306P	Syllabus Version			
		1.0			

Course Objectives:

1. To familiarize the students with the basic terminologies and concepts of OSI, TCP/IP reference model and functions of various layers.
2. To make the students understand the design and performance issues associated with the functioning of LANs and WLANs.
3. To introduce the students to analyze the IP addressing and basics of transport and application layer protocols.

Course Outcome:

The students will be able to:

1. Infer the basic concepts of OSI and TCP reference model in computer network protocols and internetworking devices.
2. Examine the LAN bridges such as Transparent Bridges and Source Routing Bridges
3. Deploy the error & flow control mechanism and medium access control.
4. Configure the network with IP address and find the shortest path.
5. Analyze transport layer protocols and congestion control algorithms
6. Understand the fundamentals of DNS, FTP, SMTP, HTTP and network security.

Module:1	**Layered Network Architecture**	**6 hours**

Evolution of data Networks – Network Topologies –Switching Techniques – Multiplexing – Categories of networks – ISO/OSI Reference Model – TCP/IP Model – Addressing – Network performance metrics.

Module:2	**Internetworking devices**	**5 hours**

Repeaters – Hubs – Switches – Bridges: Transparent and Source Routing– Routers.

Module:3	**Data Link Layer-** Logical Link Control	**6 hours**

Error Detection Techniques – ARQ protocols – Framing – HDLC –Point to Point protocol.

Module:4	**Data Link Layer-** Medium Access Control	**8 hours**

Random access Protocols – Ethernet (IEEE 802.3) – Wireless LAN (IEEE 802.11); Scheduling approaches to MAC – Controlled Access – Token Bus/Ring (IEEE 802.4/5).

Module:5	**Network Layer**	**8 hours**

Internetworking – IP Addressing – Subnetting – IPv4 and IPv6– Routing – Distance Vector and Link State Routing – Routing Protocols.

Module:6	**Transport Layer**	**5 hours**

Connection oriented and Connectionless Service – User Datagram Protocol – Transmission Control Protocol – Congestion Control – QoS parameters.

Module:7	**Application Layer**	**5 hours**

Domain Name System – Simple Mail Transfer Protocol – File Transfer Protocol – Hypertext Transfer Protocol; Network Security and Cryptography– Virtual LAN – VPN – Enterprise Network: Types and Trends – Private Network.

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture:	**45 hours**

Text Book(s)			
1.	Alberto Leon-Garcia, Communication Networks, 2017, 2nd Edition, Tata McGraw-Hill, USA.		
Reference Books			
1.	Dimitri P. Bertsekas & Robert Gallager, Data Networks, 2013, 2nd Edition, Prentice Hall, USA.		
2.	W. Stallings, Data and Computer Communications, 2017, 10th Edition, Pearson Prentice Hall, USA.		
3.	Behrouz A Forouzan, Data Communications and Networking, 2017, 5th Edition, Tata McGraw-Hill, USA.		
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE401P	Computer Communications and Networks Lab	0	0	2	1
Pre-requisite	BECE306L, BECE306P	Syllabus Version			
		1.0			

Course Objectives:

1. To familiarize the students with the basic terminologies and concepts of OSI, TCP/IP reference model and functions of various layers.
2. To make the students understand the design and performance issues associated with the functioning of LANs and WLANs.
3. To introduce the students to analyze the IP addressing and basics of transport and application layer protocols.

Course Outcome:

The students will be able to:

1. Analyze the performance of internetworking devices and network topologies using simulation tools.
2. Analyze the performance of error detection and medium access control protocols using simulation tools.
3. Implement and analyze the routing algorithms and transport layer protocols using simulation tools.

List of Challenging Experiments (Indicative)

Task 1	Simulation and performance analysis (in terms of PDR, delay) of different network topologies and queuing mechanisms.	**6 hours**
Task 2	Analyze the spanning tree algorithm by varying the priority among the switches.	**4 hours**
Task 3	Simulation of framing and error detection schemes.	**4 hours**
Task 4	Simulation and performance analysis of different Medium Access Control schemes.	**4 hours**
Task 5	Implementation of various routing algorithms to compute the shortest path.	**6 hours**
Task 6	Analysis of transport layer protocols and congestion control.	**6 hours**
	Total Laboratory Hours	**30 hours**

Mode of Assessment: Continuous Assessment and Final Assessment Test

Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE208E	Data Structures and Algorithms	2	0	2	3
Pre-requisite	BCSE101E	Syllabus version			
		1.0			

Course Objectives

1. To emphasize the scope and significance of Data Structures and Algorithms for real world problems.
2. To enable a good understanding of the fundamental data structures.
3. To enable a study of algorithms for various kinds of applications.
4. To impart skill to theoretically analyze and evaluate performance of algorithms

Course Outcome

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

1. Identify a suitable data structure technique that can solve a given problem.
2. Design an efficient algorithm for a given problem statement. For given problem develop algorithms and theoretically analyze the efficiency.
3. Develop efficient algorithms for handling different formats of data like text, numbers etc.
4. Learn the systematic way of organizing large amounts of data.
5. Correlate and map real word problems to algorithmic solutions.
6. Provide efficient algorithmic solution for real-world problems.

Module:1	Implementing Data Structures	5 hours

Linked list, Stack, Queues, Trees, Maps, Hash Tables.

Module:2	Algorithm Analysis	3 hours

Analysis Algorithms - Asymptotic notations – Recurrences -Substitution - Recursion-tree – The master method

Module:3	Algorithms with Numbers	3 hours

Sorting and Searching- Insertion sort, Binary Search, Divide and Conquer algorithms-Merge sort, Quick Sort.

Module:4	Algorithms on Strings	4 hours

Pattern Matching- KMP, Rabin-karp algorithm, Huffman Encoding.

Module:5	Graph Algorithms	5 hours

Decomposition of graphs, Paths in graphs: BFS & DFS, Minimum Spaiining Algorithms: Prim's & Kruskals's - Single-Source (Dijktra's) & All-pairs (Floyd & Warshal's).

Module:6	Algorithms for Optimization	5 hours

Brute force, Dynamic programming, Greedy algorithms: Fractional Knapsack & Linear programming.

Module:7	Search Heuristics	3 hours

Introduction to NP Completeness, Search Heuristics, Intelligent exhaustive search, Local search heuristics.

Module:8	Contemporary issues	2 hours

	Total Lecture hours:	30 hours

Text Book(s)		
1.	Introduction to Algorithms, Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, MIT Press, Fourth edition ,2022	
2.	Mark A. Weiss, Data Structures & Algorithm Analysis in C++, 4th Edition, 2013, Pearson Education.	
Reference Books		
1.	Michael T Goodrich, Roberto Tamassia & Michael H Goldwasser, Data Structures and Algorithms in Java, Wiley 2014.	
2.	Kent. D. Lee, Steve Hubbard, Data Structures and Algorithms with Python, Springer, 2015.	
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test		
Indicative Experiments		
1.	Implementing Linked list - Stacks & Queues, Trees, Maps & Hash Tables by demonstrating applications for each.	**12 hours**
2.	Performance evaluation of Divide and Conquer Algorithms	**4 hours**
3.	Text Processing - Compression & Encryption	**4 hours**
4.	Implementing Graph Algorithms	**3 hours**
5.	Implementation of Algorithms: Dynamic Programming, Greedy & Linear Programming	**3 hours**
6.	Search Algorithms	**4 hours**
	Total Laboratory Hours	**30 hours**
Mode of Assessment: Continuous Assessment and Final Assessment Test		
Recommended by Board of Studies	14-05-2022	
Approved by Academic Council	No. 66	Date 16-06-2022

Course Code	Course Title	L	T	P	C
BECE209E	Structured and Object Oriented Programming	2	0	4	4
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives:

1. To summarize the usefulness of branching and looping statements in one dimension and multi-dimensional array programming.
2. To equip students with dynamic memory management through an expertise on pointers.
3. To introduce students the importance of polymorphism and inheritance in an object oriented programming.
4. To teach students the way of supervising exceptions through exception handlers and files through file handlers.

Course Outcomes:

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

1. Implement branching and looping statements to handle 1D and 2D arrays.
2. Realize the importance of pointers to manage the memory dynamically.
3. Comprehend the use of structures and unions to encapsulate different data types in programming.
4. Apply polymorphism and inheritance which are imbibed in object oriented programming.
5. Infer and handle different exceptions.
6. Access files in terms reading and writing through various file handlers.
7. Comprehend various elements of object-oriented programing paradigm and propose solutions through inheritance and polymorphism.

Module:1	C Programming Fundamentals, Arrays and Strings	4 hours

Variables - Reserved words, Data Types, Operators, Operator Precedence - Expressions - Type Conversions - I/O statements - Branching and Looping: if, if-else, nested if, if-else ladder, switch statement, goto statement - Loops: for, while and do...while, break and continue statements. Arrays: One Dimensional array - Two-Dimensional Array — Strings and its operations.

Module:2	Functions and Pointers	4 hours

User Defined Functions: Declaration — Definition — call by value and call by reference - Types of Functions - Recursive functions - Storage Classes - Scope, Visibility and Lifetime of Variables. Declaration and Access of Pointer Variables, Pointer arithmetic — Dynamic memory allocation — Pointers and arrays - Pointers and functions.

Module:3	Structures and Unions	3 hours

Declaration, Initialization, Access of Structure Variables - Arrays of Structure - Arrays within Structure - Structure within Structures - Structures and Functions — Pointers to Structure.

Module:4	Overview of Object-Oriented Programming	6 hours

Features of OOP - Classes and Objects - “this” pointer - Constructors and Destructors - Static Data Members, Static Member Functions and Objects - Inline Functions — Call by reference - Functions with default Arguments - Functions with Objects as Arguments - Friend Functions and Friend Classes. Dynamic Memory Allocation.

Module:5	Inheritance and Polymorphism	6 hours

Inheritance - Types of Inheritance: Single inheritance, Multiple Inheritance, Multi-level Inheritance, Hierarchical Inheritance - Multipath Inheritance - Inheritance and constructors

Module:6	**Generic Programming**	**4 hours**
Function templates and class templates, Standard Template Library.		
Module:7	**Exception handling and files**	**3 hours**
Introduction to exceptions, Try and catch blocks, throw statement, File handling functions. Sequential and Random access.		
	Total Lecture hours:	**30 hours**

Text Book	
1	Herbert Schildt, C: The Complete Reference, 2017, 4th Edition, McGraw Hill Education.
2	Herbert Schildt, C++: The Complete Reference, 2017, 4th Edition, McGraw Hill Education.
Reference Books	
1	Yashavant Kanetkar, Let Us C: 2020, 17th Edition, BPB Publications, 2020.
2	Stanley Lippman and Josee Lajoie, C++ Primer, 2012, 5th Edition, Addison-Wesley publishers
3	Byron S Gottfried, Programming with C, 2018, 2018, 4th Edition, Schaum's outline series.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test

Indicative Experiments	
1.	Programs using basic control structures, branching and looping
2.	Experiment the use of 1-D, 2-D arrays and strings and Functions
3.	Demonstrate the application of pointers
4.	Experiment structures and unions
5.	Programs on basic Object-Oriented Programming constructs.
6.	Demonstrate various categories of inheritance
7.	Program to apply kinds of polymorphism.
8.	Develop generic templates and Standard Template Libraries.
9.	Demonstrate the use of Exception handling.
10.	Demonstrate the working of file handling.

Total Hours	**60 hours**

Mode of Assessment: Continuous Assessment and Final Assessment Test

Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE309L	Artificial Intelligence and Machine Learning	3	0	0	3
Pre-requisite	BMAT201L	Syllabus version			
		1.0			

Course Objectives

1. To get acquainted with different types of intelligent agents.
2. To understand the importance and significance of Machine learning.
3. To preface the essentials of Deep Learning.

Course Outcome

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

1. Comprehend different intelligent agents and its variants.
2. Solve the real-world problem using the various search algorithms.
3. Infuse various symbolic knowledge representation.
4. Employ intelligent agents for decision making.
5. Handle real-time issues using various learning methodologies.
6. Apply deep learning algorithms for solving real-world problems.

Module:1	**Foundations of AI**	**4 hours**

Introduction – Agents and rationality – Task environment – Agent Architecture Types.

Module:2	**Problem-solving by Searching**	**7 hours**

Search Space – Search algorithms, strategies – Search in complex environments.

Module:3	**Knowledge Representation**	**6 hours**

Knowledge-based agents, Agents based on Propositional Logic – First-order logic.

Module:4	**Probability reasoning and uncertainty**	**6 hours**

Quantifying uncertainty, Knowledge representation in uncertainty, Decision making – Simple, complex.

Module:5	**Data Preparation for Machine Learning**	**4 hours**

Basics of Vectors & Matrices – Overview: Data Cleaning, Integration, Transformation & Reduction.

Module:6	**Learning from Examples**	**9 hours**

Forms of Learning – Dimensionality reduction - Regression – Statistical Methods: Naïve-Bayes, Nearest Neighbor, Decision Trees – Random Forest, Clustering, Ensemble Learning, Case studies – Machine Learning in Signal Processing, Intelligent Antenna.

Module:7	**Deep Learning**	**7 hours**

Simple Feed Forward Networks – Computational graphs for Deep Learning – Convolutional Networks – Recurrent Neural Networks – Kernel Machines – Hidden Markov Models.

Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1. Stuart J Russell, Peter Norwig, Artificial Intelligence – A modern approach, 2015, 3rd edition, Pearson, India.

Reference Books

1. Vinod Chandra S.S, Anand Hareendran S., Artificial Intelligence: Principles and

	Applications, 2020, 2nd Edition, PHI Learning Pvt. Ltd., India.		
2.	Alpaydin ethem, Introduction to Machine Learning, 2019, 3rd edition, PHI Learning Pvt. Ltd., India.		
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE310L	Satellite Communications	3	0	0	3
Pre-requisite	BECE306L, BECE306P	Syllabus version			
		1.0			

Course Objectives

1. To learn the conceptual knowledge of communication through satellites.
2. To provide a detailed understanding of navigation - both inertial and by navigation satellites.
3. To analyze typical challenges of satellite based systems.

Course Outcomes

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

1. Analyse the concept of orbits, launch vehicles and satellites
2. Comprehend the design of satellite subsystems
3. Imbibe the basics of digital transmission related to satellite communication
4. Analyse the navigation satellite services.
5. Analyse the impact of diverse parameters on satellite link design
6. Apply the satellite systems for various applications

Module:1	Orbital Mechanics	6 hours

Overview of satellite communication - Orbital mechanics - Equations of the orbit - Kepler's laws of planetary motion - Orbital elements - Look angle determination - Orbital perturbation and determination

Module:2	Orbital Launchers	3 hours

Launches and launch vehicles- Launch vehicle selection factors - Satellite positioning into geostationary orbit - Orbital effects in communication systems performance - Doppler shift -Range variations - Solar eclipse and sun transit outage.

Module:3	Elements of Communication Satellite Design	5 hours

Satellite subsystems - Attitude and orbit control electronics - Telemetry and tracking - Power subsystems - Communication subsystems - Satellite antennas - Reliability and redundancy- Frequency modulation techniques.

Module:4	Digital Transmission Basics	4 hours

Modulation and Multiplexing -Multiple access techniques – FDMA, TDMA, CDMA, SDMA, ALOHA and its types – Onboard processing- Satellite switched TDMA – Spread spectrum transmission and reception for satellite networks.

Module:5	Satellite Link Design	9 hours

Basic transmission theory – System noise temperature and G/T Ratio- Noise figure and noise temperature- Calculation of system noise temperature – G/T ratio for earth stations - Link budgets - Uplink and downlink budget calculations - Error control for digital satellite links - Prediction of rain attenuation and propagation impairment counter measures.

Module:6	VSAT and NGSO System	7 hours

Overview of VSAT systems-VSAT Network Architectures, One Way Implementation, Two-Way Implementation, Delay Considerations, VSAT Earth Station Engineering -NGSO Satellite Systems Constellation/ Constellation Design Considerations - Starlink, One Web

Module:7	Direct Broadcast Satellite Television systems and GPS	9 hours

DBS Satellite Systems: DVB-S2X Standards -System Design for High-Throughput Applications , Antenna Considerations, Modulation Scheme Considerations, Error Coding Considerations, Remote Sensing Application, Navigation Satellite Systems GPS-Position Calculations and Accuracy, Navigation Messages, Receiver Design,- IRNSS		
Module:8	**Contemporary Issues**	**2 hours**
Lecture hours:	**Total**	**45 hours**

Text Book(s)	
1.	Pratt, C.W. Boastian and Jeremy Allnutt “Satellite Communication”, 2018, 2nd edition, John Wiley and Sons, Bangalore, India.
Reference Books	
1.	D.Roddy, “Satellite Communications”, 2011, 4th edition (sixth reprint), Tata McGraw Hill, New York.
2.	Anil K. Maini, Varsha Agrawal, “Satellite Communications”, 2018, Wiley India Pvt. Ltd, New Delhi, India
3	G. Maral, M. Bousquet, Z. Sun, “Satellite Communications Systems: Systems, Techniques and Technology”, 2020 (6th Edition), John Willy and sons, New York.
4	Teresa M. Braun ,”Satellite Communications Payload and System”, 2021, 2nd edition, John Wiley and Sons, USA
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test	

Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE311L	Radar Systems	3	0	0	3
Pre-requisite	BECE305L, BECE305P	Syllabus version			
		1.0			

Course Objectives

1. To understand and analyze various radar parameters.
2. To analyze and design transmitter, receiver circuits and antennas for various radars.
3. To understand and contrast the need for modern radars for different applications.

Course Outcomes

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

1. Analyze the radar range equation and radar cross section.
2. Analyze radar parameters to design and conduct radar experiments.
3. Evaluate the performance of transmitter and receiver circuits.
4. Realize various signal and data processing steps involved in the recovery of a signal.
5. Analyze and design antennas for different radars.
6. Distinguish modern radars for diverse applications.

Module:1	**Principles of Radar**	**6 hours**

Introduction to Radars, Radar principle, Doppler Effect, Radar frequency bands, Radar Block Diagram, Radar Range Equation, Radar Cross section of targets, Radar Clutter, types of scattering, Applications of Radars

Module:2	**Radar Parameters**	**6 hours**

Transmit pulse width, Pulse Repetition Frequency, baud length, range resolution, unambiguous range, coherent integration, FFT points, incoherent integration, detectability, SNR, receiver bandwidth, Transmit power, Pulse compression techniques.

Module:3	**Transmit and Receive modules(TRM)**	**8 hours**

Block schematic, Timing and signal generation for TRM operation, Gain and phase control, Design of power amplifiers, Transmit-receive switch, circulator, blanking switch, types of amplifiers (linear amplifiers, low noise amplifiers and solid-state amplifiers), and band pass filter.

Module:4	**Signal & Data Processing**	**6 hours**

Digital receiver and signal processing steps, DC and clutter removing, spectrum cleaning, computation of spectral moments, computation of velocity, range time intensity (SNR) computation, cross correlation and autocorrelation, capon imaging, maximum entropy method for imaging.

Module:5	**Radar Antennas**	**8 hours**

Antenna parameters for Radars, Parabolic Reflector antenna, Yagi-Uda antenna, Microstrip patch antenna, Phased array system: Planar Arrays, Electronic beam steering, Beam forming, Phase Shifters, Active Phased array and Semi active phased array system, Radomes.

Module:6	**Types of Radars**	**6 hours**

Principle of operation, Block diagram, Advantages, limitations and Application of CW Radar, Pulsed Radar, MTI Radar, Synthetic Aperture Radar, and Meteorological Radars(MST and Doppler weather radar).

Module:7	**Stealth Technology**	**3 hours**

Principles, Radar cross section reduction, RF absorbers and Radar stealth countermeasures and limits.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Merrill Skolnik, Introduction to Radar Systems, 3rd Edition, McGraw-Hill, USA, 2017.
Reference Books	
1.	Habibur Rahman, Fundamental Principles of Radar, CRC Press, Taylor & Francis Group, USA, 2019.
2.	Merrill Skolnik, Radar Handbook, 3rd Edition, McGraw-Hill, USA, 2008
3.	Mark A. Richards, James A. Scheer, William A. Holm (Editors), Principles of Modern Radar Vol. I: Basic Principles, SciTech Publishing, Inc, USA, 2016.
4.	G.S.N. Raju, Radar engineering and fundamentals of navigational aids, DreamTech Press (Wiley distribution), New Delhi, India, 2019.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test

Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE312L	Robotics and Automation	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To provide basic understanding of robotics and automation.
2. To demonstrate the need of various sensors and drives in robotic system.
3. To make students understand about the robotic kinematics, path planning and different trajectories.
4. To deliver the programming languages to design robots in practice and research for contemporary use.

Course Outcomes

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

1. Classify robots and summaries their role in diverse applications
2. Infer the working of basic electric, electronic, and other types of drives required in robots.
3. Distinguish and interpret the sensors for various applications in robotics and automation.
4. Determine the mathematical model of robotic systems and analyze their kinematic behavior.
5. Design robots for varied working environments encompassing all types of motions across different paths and diverse trajectories.
6. Apply the ideas in performing various robotic tasks for contemporary industry standards using suitable programming skills.

Module:1	Robotics and Automation	5 hours

Robots: Basics, Types-Application, Mobility, D o F , Terrain, components classification, performance characteristics, Industrial Robots, HRI, Automatic assembly system.

Module:2	Drives for Robotics	5 hours

Drives: Electric, hydraulic and pneumatic drives.

Module:3	Sensors for Robots	7 hours

Tactile sensors - Proximity and range sensors – Optical Sensor- limit switch sensor- surface array sensor- Acoustic sensors - Vision sensor systems – Vision feedback system -Image processing and analysis - Image data reduction – Segmentation – Feature extraction -Object recognition.

Module:4	Robot Kinematics and Dynamics	10 hours

Kinematics of manipulators, rotational, translation and transformation Homogeneous, Transformations, Denavat – Hartenberg Representation, Inverse Kinematics. Linearization of Robot Dynamics – State variable continuous and discrete models.

Module:5	Path Planning	5 hours

Types of trajectories, trajectory planning and avoidance of obstacles, path planning, skew motion, joint integrated motion and straight line motion.

Module:6	Programming of Robots	5 hours

Robot programming: ROS1 and ROS2, languages and software packages- MATLAB/Simulink, OpenRDK, Adams.

Module:7	Application of Robots	6 hours

Industrial robots used for welding, painting and assembly, remote controlled robots, robots for nuclear, thermal and chemical plants, industrial automation, typical examples of automated Industries, Humanoid robots, medical robots, under water robots, drones.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Kevin M. Lynch, Frank C. Park, "Modern Robotics- Mechanics, Planning, and Control", 2017, Cambridge University Press.
Reference Books	
1.	R. K. Mittal, I. J. Nagrath, "Robotics and Control", 2017, McGraw Hill Education, India,
2.	Ramkumar Gandhinathan, Lentin Joseph, "ROS Robotics Projects-Build and Control Robots Powered by the Robot Operating System, Machine Learning, and Virtual Reality", 2019, Packt Publishing.
3.	Hutchinson, S., Spong, M. W., Vidyasagar, M. "Robot Modeling and Control", 2020, Wiley publications, United Kingdom.
4.	Pawlak, A. M. Sensors and Actuators in Mechatronics: Design and Applications, 2017, CRC Press, United Kingdom.
5.	Lentin Joseph, "Robot Operating System (ROS) for Absolute Beginners - Robotics Programming Made Easy, 2018, Apress.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test

Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE313L	Information Theory and Coding	3	0	0	3
Pre-requisite	BECE306L, BECE306P	Syllabus version			
		1.0			

Course Objectives

1. This course provides an understanding of fundamental information theoretic techniques including applications to compression and error control coding.
2. It also aims at quantitative measure of information may be used in order to build efficient solutions to multitudinous engineering problems.

Course Outcomes

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

1. Analyze probability theory and evaluate the average and mutual information.
2. Examine different types of channels and determine their capacity.
3. Implement various types of source coding algorithms and analyze their performance.
4. Apply various types of coding techniques and standards on audio and video.
5. Design linear block codes and cyclic codes (encoding and decoding).
6. Design and build the channel coder for 5G standard.

Module:1	Information Measures	7 hours

Review of Probability Theory, Introduction to information theory, Uncertainty, self-information, average information, Marginal Entropy, Joint Entropy and Conditional Entropy, Mutual Information, Relationship between entropy and mutual information and their properties, Markov statistical model for information source, Entropy and information rate of markov source , Information measures of continuous random variables.

Module:2	Channel Models and Capacity	6 hours

Importance and types of various channel models - Channel capacity calculation – Binary symmetric channel, binary erasure channel - Shannon's channel capacity and channel coding theorem - Shannon's limit.

Module:3	Probability based Source Coding	6 hours

Source coding theorem - Huffman coding - Non binary Huffman codes - Adaptive Huffman coding - Shannon Fano Elias coding - Non binary Shannon Fano codes, Arithmetic coding

Module:4	Non Probability based Source Coding	5 hours

Lempel-Ziv coding, Run-length encoding and rate distortion function - Transform coding - JPEG and JPEG 2000.

Module:5	Audio and Video Coding	5 hours

Audio Coding: types – Linear Predictive Coding (LPC) – Code Excited LPC – Perceptual Coding - MPEG Audio Coding. Video Coding: Motion Estimation and Compensation – Types of Frames – Encoding and Decoding of Frames – Video Coding Standard: MPEG 4.

Module:6	Channel Coding	9 hours

Introduction to Error control codes - Block codes, linear block codes, cyclic codes and their properties, Encoder and Decoder design- serial and parallel concatenated block code, Convolution Codes- Properties, Encoder-Tree diagram, Trellis

diagram, state diagram, transfer function of convolutional codes, Viterbi Decoding, Trellis coding, Reed Solomon codes, Turbo coder, Iterative Turbo decoder		
Module:7	**Channel Coding for 5G standard**	**5 hours**
Low Density Parity Check code - LDPC code construction, construction in 5G standard, encoding of LDPC codes, Message passing decoding on Tanner graph. Polar code – Representation, generator matrix, Successive cancellation decoder for polar codes.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1	Simon Haykin, “Communication Systems”, 2017, 5th Edition, Wiley India Pvt Ltd, India.
2	Khalid Sayood, “Introduction to Data Compression, 5th Edition, The Moragan Kaufmann Series in Multimedia Information and Systems, Elsevier, 2017.
Reference Books	
1.	Ranjan Bose, “Information Theory, Coding and Cryptography”, 2015, 1st Edition, McGraw Hill Education (India) Pvt. Ltd., India.
2	Murlidhar Kulkarni, K.S. Shivaprakasha, “Information Theory and Coding As per AICTE”, 2019, 2nd Edition, Wiley India Pvt Ltd, India.
3	Orhan Gazi, “Polar Codes: A Non-Trivial Approach to Channel Coding”, 2019, 1st Edition, Springer Topics in Signal Processing Book 15.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE314L	Electromagnetic Interference and Compatibility	2	1	0	3
Prerequisite	BECE205L	Syllabus Version			
		1.0			

Course Objectives

1. To understand importance of EMC and EMC compliance for the products.
2. To understand guidelines for reduced EMI in PCB design
3. To learn the EMI sources, mitigation, and measurement techniques/standards to guarantee the correct working modalities.

Course Outcomes

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

1. Understand the concepts related to EMI and EMC
2. Analyze the various coupling methods
3. Apply a proper EMI control technique for a specific identified EMI issue.
4. Apply the guidelines for PCB Design
5. Familiarize with EMC Measurement Techniques
6. Identify various emission and susceptibility testing standards which a product should comply with

Module 1	EMI/EMC Concepts	4 Hours

EMI/EMC definitions – Units - Sources of EMI: Classification, Lightning, ESD, NEMP - Conducted and radiated emission - Conducted and radiated susceptibility – Intra and inter system EMI - In band interference - Spectrum conservation - Radiation hazard - Specific Absorption Rate (SAR).

Module 2	EMI Coupling Principles	4 Hours

Conductive coupling: Common-mode**,** Differential-mode - Inductive coupling - Capacitive coupling - Radiative coupling

Module 3	EMI Control Techniques -I	8 Hours

Grounding: Earthing principle, Types of Grounding- system grounding - Shielding: Shielding theory and shielding effectiveness, Shielding integrity at discontinuities, Conductive coatings, Cable shielding, Bonding: Shape and material for bond strap - general guidelines for good bonds.

Module 4	EMI Control Techniques -II	8 Hours

EMI Filters: Characteristics of filters, Impedance mismatch effects, Lumped element filters, Power line filter design, Common mode filter, Differential mode filter - EMI suppression devices and components: EMI suppression cables, EMC connectors, EMC gaskets, Isolation transformers, Transient and surge suppression devices.

Module 5	EMC Design of PCBs	8 Hours

RF Sources in PCB - SMD / through hole components, Pins, Basic loops, Differential vs Common mode - Board layout: Ground plane and Power plane, ground bounce, Power distribution for two-layer boards, Power supply decoupling, Board zoning, Signal traces, Cross talk, Trace routing - Cables and connectors.

Module 6	EMI Measurements	5 Hours

Radiated interference measurements: Open area test site measurement, anechoic chamber, TEM cell; Reverberating chamber - Conducted interference measurements: Characterization of conduction currents voltages, Conducted EM noise on power supply lines, Conducted EMI from equipment - Pulsed interference immunity: ESD/EFT, Electrical surge - Time domain EMI measurement

Module 7	**EMC Standards**	**4 Hours**
Military standards, IEEE/ ANSI Standards, CISPR/IEC, FCC standards, European Standards, VDE Standards, Other EMC Standards, Company Standards, EMC compliance for wireless devices, Radio Equipment Directive (RED).		
Module 8	**Contemporary Issues**	**2 Hours**
	Total Lecture Hours	**45 Hours**
Text Books:		
1.	Clayton R.Paul, “Introduction to Electromagnetic Compatibility”, Wiley-Interscience, 2022	
Reference Books:		
1.	Henry W.Ott., “Electromagnetic Compatibility Engineering”, Wiley, 2009.	
2.	V.P.Kodali, “Engineering Electromagnetic Compatibility: Principles, Measurements, Technologies, and Computer Models”, Wiley-IEEE Press, 2001	
3.	Christos Christopoulos, “Principles and Techniques of Electromagnetic Compatibility”, CRC Press, 2007.	
4.	Mark I. Montrose, “EMC Made Simple Printed Circuit Board and System Design”, Montrose Compliance Services, 2014.	
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test		

Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE315L	Optical Networks	3	0	0	3
Pre-requisite	BECE308L, BECE308P/ BECE318L, BECE318P	Syllabus version			
		1.0			

Course Objectives

1. To introduce Optical Components, Transmission system Engineering and Optical Digital Networks.
2. To design Optical WDM Networks and to understand the routing techniques.
3. To elucidate about Optical packet switching, OTN and access networks.
4. To analyze the various optical network performances and to understand traffic management, fault management and security.

Course Outcomes

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

1. Identify the optical components and analyze the transmission system.
2. Analyze the various Optical Digital Networks
3. Design Optical WDM Networks and to understand the routing techniques.
4. Understand Optical packet switching, OTN and access networks.
5. Analyze the various optical network performance and to understand traffic management.
6. Identify the faults in optical networks and select the suitable protection techniques.

Module:1	**Optical system components**	**6 hours**

Optical System Components – Couplers, Isolators & Circulators, Multiplexers & Filters, Optical Amplifiers, Switches, Wavelength Converters; Transmission System Engineering – System model, Power penalty - transmitter, receiver, Optical amplifiers, Overall design considerations.

Module:2	**Optical digital networks**	**6 hours**

Introduction to Optical Networks; SONET / SDH, Metropolitan-Area Networks, Layered Architecture; Broadcast and Select Networks – Topologies, Media-Access Control Protocols and Testbeds; Wavelength Routing Architecture.

Module:3	**Wavelength routing networks**	**6 hours**

WDM Network Design - Cost tradeoffs, Virtual Topology Design, Routing and wavelength assignment, Statistical Dimensioning Models.

Module:4	**Packet switching and access networks**	**6 hours**

Photonic Packet Switching – OTDM, Multiplexing and De-multiplexing, Synchronization, Header Processing, Buffering, Burst Switching, Testbeds; Access Networks.

Module:5	**Optical transport network and network synchronization**	**6 hours**

Introduction- OTN Network Layers - FEC in OTN- OTN Frame Structure- OTN and DWDM- OTN Management- Synchronization - The Timing Signal- Signal Quality- Transmission Factor- Jitter and Wander- Photodetector Responsivity and Noise Contributors.

Module:6	**Network performance**	**8 hours**

Introduction-Channel Performance- Power-Bandwidth Ratio- Shannon's Limit - Optical Signal to Noise Ratio - Factors That Affect Channel Performance - Analysis of BER and SNR Related to Channel Performance - BER and SNR. **Traffic Management and Control**-Client Bandwidth Management -Wavelength Management – Paths with --Congestion Management - Routing Discovery of Optical Network -Node and Network - Wavelength Management Strategies.		
Module:7	**Network protection, fault management and security**	**5 hours**
Introduction- Fault Detection and Isolation - Fault and Service Protection - Point-to-Point Networks- Mesh Network Protection -Ring-Network - Ring-to-Ring Protection - Multi-ring Shared Protection - Network Security Issues - Definitions -Security - Security Layers in Communication Networks.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Debasish Datta, “Optical Networks”, OUP Oxford (2021), 1st Edition.
Reference Books	
1.	Biswanath Mukherjee, "Optical WDM Networks", Springer, 2006. 1st Edition.
2.	Stamatios V. Kartalopoulos "Next Generation Intelligent Optical Networks” Springer Science Business Media. LLC, 2008, 1st Edition.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test

Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No.69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE316E	Digital Image Processing	3	0	2	4
Pre-requisite	BECE301L,BECE301P	Syllabus version			
		1.0			

Course Objectives

1. To learn the fundamentals of Digital image processing in spatial and frequency domain.
2. To apply various filtering methods for image enhancement.
3. To understand the concepts of color image processing and different image compression techniques.
4. To apprehend various image segmentation algorithms and the concept of descriptors.

Course Outcomes

At the end of the course, Students will have the ability to,

1. Apply the key concepts of Digital image processing in spatial and frequency domain.
2. Compute the transform of an image by 2D-FFT, DCT, DWT and KL transform
3. Analyze the frequency domain enhancement techniques
4. Formulate the color models and to propose the desired color image processing
5. Investigate various standard image compression techniques and discriminate their effects in terms of data reduction
6. Summarize various image segmentation algorithms and to represent the same using boundary and region descriptors
7. Apply appropriate tool to implement various algorithms using the image processing concepts

Module:1	Image sampling and transformations	7 hours

Introduction, Fundamental steps in DIP – Elements of visual perception -Image sensing and Acquisition – Image Sampling and Quantization – Imaging geometry, discrete image mathematical characterization- Basic relationship between pixels. Basic Gray level Transformations – Histogram Processing – Smoothing spatial filters- Sharpening spatial filters.

Module:2	Image Transforms	7 hours

Two-dimensional Fourier Transform- Properties – Fast Fourier Transform – Inverse FFT- Discrete cosine transform and KL transform-Discrete Short time Fourier Transform. Introduction to Multiresolution analysis - Discrete Wavelet Transform- the Haar wavelet family

Module:3	Image Enhancement in Frequency domain	6 hours

Smoothing frequency domain filters- Sharpening frequency domain filters- Homomorphic filtering - Restoration filters: Bandpass – Band reject - Notch filter

Module:4	Color Image Processing	5 hours

Color models: RGB- HSI- CMYK -Pseudo color image processing- Color transformations – Smoothening and Sharpening

Module:5	Image Compression	6 hours

Overview of Image Compression Techniques- Entropy Encoding- Huffman – Arithmetic- LZW - JPEG and MPEG standards

Module:6	**Image Segmentation**	**7 hours**
Detection of discontinuities – Edge linking and boundary detection- Thresholding - Edge based segmentation - Region based segmentation- Matching- Morphological segmentation- Watershed algorithm		
Module:7	**Representation and Description**	**5 hours**
Boundary descriptors - Region descriptors - Texture descriptors - Use of Principal Components for Description.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Rafael C.Gonzalez & Richard E.Woods, "Digital Image Processing", 2017, 4th edition, Pearson Education, USA
Reference Books	
1.	Anil K.Jain, "Fundamentals of Digital Image Processing", 2015, 1st edition, Pearson India, India
2.	Mark Nixon & Alberto Aguado, "Feature Extraction, and Image Processing", 2012, 3rd edition, Elsevier's Science & Technology Publications, Woborn MA, Great Britain.
3.	Scott E Umbaugh, "Digital Image Processing and Analysis: Human and Computer Vision Applications with CVIP tools", 2011, 2nd edition, CRC press, Boca Raton, FL, USA.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test

Indicative Experiments		
1	(a) Perform point to point operation on the given image and compute the following and interpret changes in image i. Image Negative ii. Power law transformation iii. Log transformation (b) Perform contrast stretching for the given poor contrast image. (c) Perform histogram equalization for the given image and analyze the enhanced quality of the image.	**3 hours**
2	a) Read the input Image and perform Interpolation and Decimation. Show the effect of image shrinking and zooming. b) Read the input image and show the effect of gray level slicing for different levels. c) Perform Bitplane slicing for given image and comment on the number of visually significant bit planes in each image.	**3 hours**
3	Implement the following spatial domain filtering techniques for an image a) Low Pass Filtering b) High Pass Filtering c) Order Statistics (Median) Filtering	**3 hours**

4	Perform DFT for the given image and obtain its Fourier spectrum. Compute IDFT. Verify the symmetric property of DFT and compare the result with Discrete Cosine Transform (DCT).	**3 hours**
5	Removal of fine details in an image by frequency domain filtering and analysis of information loss.	**3 hours**
6	Perform image enhancement, feature extraction studies and compression using DCT.	**3 hours**
7	a) Perform image enhancement, feature extraction studies and compression using DWT. b) Perform DWT of an image, analyze and further reconstruct the image using IDWT	**3 hours**
8	Segment the region of interest from a given image using region-based segmentation and watershed algorithm.	**3 hours**
9	Identifying objects in an image based on their boundaries.	**3 hours**
10	To detect moving objects in given image frames using background subtraction algorithm.	**3 hours**
	Total Laboratory Hours	**30 hours**

Mode of assessment: Continuous assessment and FAT			
Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE320E	Embedded C Programming	2	0	2	3
Pre-requisite	NIL	Syllabus version			
		V 1.0			

Course Objectives

1. To impart logical thinking and fundamental problem-solving skills via the use of a programming language.
2. To develop basic and advanced programming concepts using C and Embedded C language.
3. To interface with microcontroller using Embedded C language.

Course Outcome

The student will be able to

1. Apply the C programming language for various data types and decision making applications.
2. Comprehend the derived data types, pointers and creation of functions.
3. Describe the architecture of 8051 microcontroller for programming & interfacing applications.
4. Write the embedded C code to 8051 for programming I/O ports, timers, serial communication, interrupt and interfacing external peripherals.
5. Develop microcontroller based applications.

Module:1	Introduction to C	3 hours

Introduction to Embedded C, difference between C and Embedded C. Introduction to C programming, comments, identifiers, variables, headers, data types, operators, order of operations, format specifies, escape sequence characters, input and output statements, programs on sequential statements.

Module:2	Control and loop statements	4 hours

Control statements: if, if-else, if-else ladder, elseif ladder, switch. Loops: do-while, while, for loops and nested loops. Break, continue, goto and exit statements. Programs on if, switch and loops.

Module:3	Arrays and strings	3 hours

Arrays: one dimensional and multi-dimensional array, programs on arrays. Strings, functions, pointers.

Module:4	Introduction to 8051 microcontroller	6 hours

Introduction to microcontroller, difference between microcontroller and microprocessor, 8051 : architecture, pin diagram of 8051, memory organization, special function registers, I/O pins ,timers, interrupts, serial interface, power consumption, external interface of the standard 8051.

Module:5	8051 programming in C	4 hours

Data types: sbit, sfr, and bit. Producing delay using loops, programming I/O ports: bit addressable and byte addressable programming, programs on sending and receiving data through I/O ports. Programs on logic operations, data conversion, data serialization with I/O ports.

Module:6	Timer and serial port programming	4 hours

Programs on accessing timers registers, programs on producing time delay using mode 1 and mode 2, programs on generating various clock frequencies, programming of timers 0 and 1 as counters. Serial port programming: transmitting and receiving data with different baud rates. Programs on timer and Serial communication interrupt.

Module:7	Interfacing with displays and sensors	4 hours

Programming of keyboard interfacing, programming of LEDs interfacing, programming of seven segment display interfacing, interfacing circuit description and programming of 16 x 2

LCD, ADC, DAC and temperature sensor interfacing.			
Module:8	**Contemporary issues**		**2 hours**
	Total Lecture hours:		**30 hours**
Text Book(s)			
1	Mike McGrath, C Programming in easy steps, 2019, 4th Edition, In Easy Steps Limited.		
2	Muhammad Ali Mazidi , Janice Gillispie Mazidi , Rolin McKinlay, 2014, The 8051 Microcontrollers & Embedded Systems , 2nd edition, Pearson.		
Reference Books			
1.	Barrett, Michaell, and Ambony Massa. Programming Embedded Systems, with C and GNU Development Tools, 2020, O'Reilly Media.		
2	Herbert Schildt, C: The Complete Reference, 2017, 4th Edition, McGraw Hill Education.		
Mode of evaluation: Internal Assessment (CAT, quizzes, Digital Assignments) & Final Assessment Test (FAT)			
Lab Component :			
Indicative Experiments			
1	Programs on Sequential statements		2 hours
2	Programs on Condition and Control statements		2 hours
3	Programs on Arrays		2 hours
4	Programs on Strings & Functions		2 hours
5	Programs on I/O ports		2 hours
6	Programs on Timer/Counter		4 hours
7	Programs on serial communication		2 hours
8	Programs on Timer Interrupts		2 hours
9	Programs on Serial Communication Interrupts		2 hours
10	Programs on External interrupts		2 hours
11	Programs on interfacing Keypad and LCDs		4 hours
12	Programs on interfacing ADC, DAC and Sensors		4 hours
	Total Laboratory Hours		**30 hours**
Mode of assessment: Continuous assessment and FAT			
Recommended by Board of Studies		07-11-2023	
Approved by Academic Council	No. XX	Date	DD-MM-YYYY

Course Code	Course Title	L	T	P	C
BECE391J	Technical Answers to Real Problems Project	0	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To gain an understanding of real-life issues faced by society.
2. To study appropriate technologies in order to find a solution to real life issues.
3. Students will design system components intended to solve a real-life issue.

Course Outcomes

1. Identify real life issue(s) faced by society.
2. Apply appropriate technologies to suggest a solution to the identified issue(s).
3. Design the related system components/processes intended to provide a solution to the identified issue(s).

Module Content **(Project Duration: Two Semesters)**

1. Students are expected to perform a survey and interact with society to find out the real life issues.
2. Logical steps with the application of appropriate technologies should be suggested to solve the identified issues.
3. Subsequently the student should design the related system components or processes which is intended to provide the solution to the identified real-life issues.

General Guidelines:

1. Identification of real-life problems
2. Field visits can be arranged by the faculty concerned
3. Maximum of 3 students can form a team (within the same/different discipline)
4. Minimum of eight hours on self-managed team activity
5. Appropriate scientific methodologies to be utilized to solve the identified issue
6. Solution should be in the form of fabrication/coding/modelling/product design/process design/relevant scientific methodology(ies)
7. Consolidated report to be submitted for assessment
8. Participation, involvement and contribution in group discussions during the contact hours will be used as the modalities for the continuous assessment of the theory component
9. Project outcome to be evaluated in terms of technical, economical, social, environmental, political and demographic feasibility
10. Contribution of each group member to be assessed

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews

Recommended by Board of Studies	12-10-2022		
Approved by Academic Council	No. 68	Date	19-12-2022

Course Code	Course Title	L	T	P	C
BECE392J	Design Project	0	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. Students will be able to upgrade a prototype to a design prototype.
2. Describe and demonstrate the techniques and skills necessary for the project.
3. Acquire knowledge and better understanding of design systems.

Course Outcomes

1. Develop new skills and demonstrate the ability to upgrade a prototype to a design prototype or working model.
2. Utilize the techniques, skills, and modern tools necessary for the project.
3. Synthesize knowledge and use insight and creativity to better understand and improve design systems.

Module Content	(Project Duration: One Semester)

Students are expected to develop new skills and demonstrate the ability to develop prototypes to design prototype or working models related to an engineering product or a process.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews.

Recommended by Board of Studies	12-10-2022		
Approved by Academic Council	No. 68	Date	19-12-2022

Course Code	Course Title	L	T	P	C
BECE393J	Laboratory Project	0	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. The student will be able to conduct experiments on the concepts already learnt.
2. Analyse experimental data.
3. Present the results with appropriate interpretation.

Course Outcomes

1. Design and conduct experiments in order to gain hands-on experience on the concepts already studied.
2. Analyse and interpret experimental data.
3. Write clear and concise technical reports and research articles

Module Content	(Project Duration: One Semester)

Students are expected to perform experiments and gain hands-on experience on the theory courses they have already studied or registered in the ongoing semester. The theory course registered is not expected to have laboratory component and the student is expected to register with the same faculty who handled the theory course. This is mostly applicable to the elective courses. The nature of the laboratory experiments is depended on the course.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews.

Recommended by Board of Studies	12-10-2022		
Approved by Academic Council	No. 68	Date	19-12-2022

Course Code	Course Title	L	T	P	C
BECE394J	Product Development Project	0	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. Students will be able to translate a prototype to a useful product.
2. Apply relevant codes and standards during product development.
3. The student will be able to present his results by means of clear technical reports.

Course Outcomes

1. Demonstrate the ability to translate the developed prototype/working model to a viable product useful to society/industry.
2. Apply the appropriate codes/regulations/standards during product development.
3. Write clear and concise technical reports and research articles

Module Content	(Project Duration: Two Semesters)

Students are expected to translate the developed prototypes / working models into a product which has application to society or industry.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews

Recommended by Board of Studies	12-10-2022		
Approved by Academic Council	No. 68	Date	19-12-2022

Course Code	Course Title	L	T	P	C
BECE396J	Reading Course	0	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. The student will be able to analyse and interpret published literature for information pertaining to niche areas.
2. Scrutinize technical literature and arrive at conclusions.
3. Use insight and creativity for a better understanding of the domain of interest.

Course Outcomes

1. Retrieve, analyse, and interpret published literature/books providing information related to niche areas/focused domains.
2. Examine technical literature, resolve ambiguity, and develop conclusions.
3. Synthesize knowledge and use insight and creativity to better understand the domain of interest.

Module Content	(Project Duration: One Semester)
This is oriented towards reading published literature or books related to niche areas or focussed domains under the guidance of a faculty.	
Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews.	
Recommended by Board of Studies	12-10-2022
Approved by Academic Council	No. 68 Date 19-12-2022

Course Code	Course Title	L	T	P	C
BECE397J	Special Project	0	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. Students will be able to identify and solve problems in a time-bound manner.
2. Describe major approaches and findings in the area of interest.
3. Present the results in a clear and concise manner.

Course Outcomes

1. To identify, formulate, and solve problems using appropriate information and approaches in a time-bound manner.
2. To demonstrate an understanding of major approaches, concepts, and current research findings in the area of interest.
3. Write clear and concise research articles for publication in conference proceedings/peer-reviewed journals.

Module Content **(Project Duration: Three Semesters)**

This is an open-ended course in which the student is expected to work on a time bound research project under the supervision of a faculty. The result may be a tangible output in terms of publication of research articles in a conference proceeding or in a peer-reviewed Scopus indexed journal.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – project report to be submitted, presentation and project reviews.

Recommended by Board of Studies	12-10-2022		
Approved by Academic Council	No. 68	Date	19-12-2022

Course Code	Course Title	L	T	P	C
BECE398J	Simulation Project	0	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. Students will be able to simulate a real system.
2. Identify the variables which affect the system.
3. Describe the performance of a real system.

Course Outcomes

1. Demonstrate the ability to simulate and critically analyse the working of a real system.
2. Identify and study the different variables which affect the system elaborately.
3. Evaluate the impact and performance of the real system.

Module Content **(Project Duration: One Semester)**

The student is expected to simulate and critically analyse the working of a real system. Role of different variables which affect the system has to be studied extensively such that the impact of each step in the process is understood, thereby the performance of each step of the engineering process is evaluated.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – project report to be submitted, presentation and project reviews.

Recommended by Board of Studies	12-10-2022		
Approved by Academic Council	No. 68	Date	19-12-2022

Course Code	Course Title	L	T	P	C
BECE403E	Embedded Systems Design	3	0	2	4
Pre-requisite	BECE204L, BECE204P	Syllabus version			
		1.0			

Course Objectives

1. To acquaint students with definition, characteristics, challenges and design lifecycle of Embedded Systems by imparting the fundamental knowledge of I/O interfacing, serial communication protocols, wireless technologies, design using UML models
2. To familiarize the concepts and features of Real-time operating systems, task scheduling, and inter-task communication.
3. To impart various programming tools, modeling and simulation packages to program, design, simulate and build Embedded Systems

Course Outcomes

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

1. Design any application, based on the given specifications by keeping in mind different design metrics.
2. Apply the skills attained to differentiate Microprocessor/Microcontroller and interface various peripherals for a particular application.
3. Demonstrate proficiency in using device drivers, firmware and debugging tools.
4. Analyze the specific perspective of the embedded application using different modelling languages
5. Compare and contrast various wired and wireless protocols
6. Explore the concepts of RTOS and apply the knowledge for developing real-time systems

Module:1	**Embedded System Product Development**	**4 hours**

Characteristics of embedded systems, Classification of embedded systems, Embedded product development cycle, Embedded System Design Challenges, Performance and Benchmarking Tools.

Module:2	**Embedded Hardware Design**	**5 hours**

Processor classification - general purpose, customized, application specific processors, Microcontroller architectures (RISC, CISC), Embedded Memory, Strategic selection of processor and memory, Power Supply Design Considerations for Embedded Systems.

Module:3	**Embedded Software Development Environment**	**6 hours**

Cross assemblers/compilers, Linker, Runtime Library, Pre-processor Workflow, make files, Compiler Tool chains – gcc & ARM, Device Driver, Firmware, Middleware - Debugging tools: Emulators, Simulators, In-Circuit Debuggers, Logic Analyzer, Integrated Development Environment (IDE).

Module:4	**Modeling Embedded Systems**	**6 hours**

Control data flow graph, Finite state machine model, Petrinet Model, Unified model language

Module:5	**Programming the Peripherals of Microcontrollers**	**6 hours**

Programming GPIO pins, Timers / Counters, Watchdog Timer, PWM generation, ADC, DAC, LED, switches, keypad, LCD.

Module:6	**Emerging Communication Protocols**	**8 hours**

UART, SPI, I2C, NFC, CAN, Bluetooth, Zigbee, Wi-Fi				
Module:7	**Embedded Real –Time Operating Systems**			**8 hours**
Introduction to basic concepts of RTOS- Task, process & threads, Multiprocessing and Multitasking, Preemptive and non-preemptive scheduling, Schedulability Analysis, Inter process Communication, Performance Metrics of RTOS				
Module:8	**Contemporary Issues**			**2 hours**
	Total Lecture hours:			**45 hours**
Text Book(s)				
1.	Raj Kamal, “Embedded systems Architecture, Programming and Design”, 2017, Third Edition, McGraw Hill Education, India.			
Reference Books				
1.	Marilyn Wolf, “Computers as components: Principles of Embedded Computing System Design”, 2017, Fourth Edition, Morgan Kaufmann publications (Elsevier), United States.			
2.	Jiacun Wang, "Real-Time Embedded Systems", 2017, First Edition, Wiley Publishers, United States.			
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test				
Indicative Experiments				
1.	Experiments based on interfacing I/O devices			**4 hours**
2.	Experiments based on monitoring and control using sensors and actuators			**6 hours**
3.	Experiments based on wired Communications Protocols (UART, SPI, I2C, CAN)			**8 hours**
4.	Experiments based wireless Communications Protocols (Wi-Fi, Bluetooth)			**6 hours**
5.	Experiments based on RTOS			**6 hours**
	Total Laboratory Hours			**30 hours**
Mode of assessment: Continuous assessment and FAT				
Recommended by Board of Studies	28-02-2023			
Approved by Academic Council	No. 69	Date	16-03-2023	

Course Code	Course Title	L	T	P	C
BECE404L	Detection, Estimation and Modulation Theory	3	0	0	3
Pre-requisite	BECE207L	Syllabus version			
		1.0			

Course Objectives

1. To familiarize the students a hypothesis testing for various signal detection models.
2. To make them understand and apply Gaussian detection scheme.
3. To make them proficient in scalar and vector parameter estimation.
4. To let them develop an expertise in Kalman filter based estimation.

Course Outcomes

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

1. Postulate the hypothesis testing.
2. Apply Gaussian detection in suitable signal processing applications.
3. Develop a scheme to estimate scalar and vector parameters using the classical scheme of parameter estimation.
4. Estimate the parameters of importance through Gaussian estimation method.
5. Design and implement the estimators for continuous time random processes.
6. Apply Kalman filter based estimation in suitable signal processing applications.

Module:1	Classical Detection Theory	6 hours

Introduction - Simple Binary Hypothesis Tests - Decision Criteria - Performance: Receiver Operating Characteristic - M Hypotheses - Performance Bounds and Approximations - Monte Carlo Simulation - Importance Sampling -Simulation of PF - Simulation of PM - Independent Observations - Simulation of the ROC, Examples, Iterative Importance Sampling.

Module:2	Gaussian Detection	8 hours

Real and Circular Complex Gaussian Random Vectors - General Gaussian Detection - Equal Covariance Matrices - Independent Components with Equal and Unequal Variances - Eigen decomposition - Optimum Signal Design - Interference Matrix: Estimator – Subtractor - Low-Rank Models - Equal Mean Vectors - Diagonal Covariance Matrix on H0: Equal Variance – Independent and Identically Distributed Signal Components - Independent Signal Components: Unequal Variances - Correlated Signal Components - Low-Rank Signal Model - Symmetric Hypotheses - Uncorrelated Noise - Nondiagonal Covariance Matrix on H0, H1, Signal on Both Hypotheses, M Hypotheses

Module:3	Classical Parameter Estimation	6 hours

Introduction - Scalar Parameter Estimation - Random Parameters: Bayes Estimation - Nonrandom Parameter Estimation - Bayesian Bounds - Lower Bound on the MSE - Asymptotic Behavior - Exponential Family - Nonrandom Parameters - Random Parameters - Summary of Scalar Parameter Estimation

Module:4	Multiple Parameter Estimation	5 hours

Multiple Parameter Estimation - Estimation Procedures - Random Parameters - Nonrandom Parameters - Measures of Error- Nonrandom Parameters - Random Parameters - Bounds on Estimation Error - Nonrandom Parameters - Random Parameters - Hybrid Parameters - Hybrid Parameters - Joint ML and MAP Estimation

Module:5	Gaussian Estimation	7 hours

Introduction - Nonrandom Parameters - General Gaussian Estimation Model - Maximum Likelihood Estimation - Crammer–Rao Bound - Fisher Linear Gaussian Model - White Noise - Low-Rank Interference - Separable Models for Mean Parameters - Covariance Matrix Parameters - White Noise - Colored Noise - Rank One Signal Matrix Plus White Noise - Rank One Signal Matrix Plus Colored Noise - Linear Gaussian Mean and Covariance Matrix Parameters - White Noise -		
Module:6	**Estimation of Continuous-Time Random Processes**	**5 hours**
Optimum Linear Processors - Realizable Linear Filters: Stationary Processes, Infinite Past: Wiener Filters - Solution of Wiener–Hopf Equation - Errors in Optimum Systems - Unrealizable Filters - Closed-Form Error Expressions		
Module:7	**Kalman Filter Based Estimation**	**6 hours**
Gaussian - Markov Processes: Kalman Filter - Differential Equation Representation of Linear Systems and Random Process Generation - Kalman Filter - Realizable Whitening Filter - Generalizations - Implementation Issues - Bayesian Estimation of Non-Gaussian Models - The Extended Kalman Filter - Linear AWGN Process and Observations - Linear AWGN Process, Nonlinear AWGN Observations		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Harry L. Van Trees, “Detection Estimation and Modulation Theory”, John Wiley, 2013.
Reference Books	
1.	Bernard C. Levy, “Principles of Signal Detection and Parameter Estimation”, Springer New York, NY, ISBN 978-0-387-76542-6, 2008
2.	H. Vincent Poor, “An Introduction to Signal Detection and Estimation”, Springer New York, NY, 1994
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test	

Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE405L	Cognitive Radio Networks	3	0	0	3
Pre-requisite	BECE307L, BECE307P/ BECE317L, BECE317P	Syllabus version			
		1.0			

Course Objectives

1. To understand the principles and importance of cognitive radio in the context of next-generation networks
2. To analyze various spectrum sensing, access and management protocols
3. To introduce the challenges and opportunities associated with cognitive radio networks

Course Outcomes

At the end of the course, the student will have the ability to

1. Solve the fundamental challenges associated with security, medium access control and network layers.
2. Analyze the performance of various spectrum access, sensing and management schemes.
3. Create the network layer suitable for CRNs.
4. Use modern tools for the implementation of spectrum access, sensing and management protocols.
5. Make a presentation on assigned topic related to this course.

Module:1	Introduction to Cognitive Radio	6 hours

Evolution of Cognitive Radio, Cognitive Radio in 4G/5G Wireless Communications, Key Applications-Interoperability, Dynamic Spectrum Access, Regulatory Issues of Cognitive Access, Cognitive radio architecture, Introduction to software defined radio (SDR)-architecture and design principles, Reconfigurable wireless communication systems

Module:2	Spectrum Access and Sharing	6 hours

Unlicensed Spectrum Sharing, Licensed Spectrum Sharing, Secondary Spectrum Access, Non-Real-Time Spectrum Access and Sharing, Real-Time Spectrum Access and Sharing- Negotiated Access, Opportunistic Access, Overlay Approach, Underlay Approach

Module:3	Spectrum Sensing and Management	8 hours

Spectrum Sensing to Detect Specific Primary System-Conventional spectrum sensing, power control, Power-scaling power control, Cooperative spectrum sensing, Spectrum sensing procedure. Spectrum Sensing for Cognitive Multi-Radio Networks-Multiple system sensing, Radio resource sensing

Module:4	Medium Access Control	7 hours

MAC for cognitive radios, Multi-channel MAC-Collision avoidance/resolution, Access negotiation, Slotted-ALOHA with Rate-Distance Adaptability, CSMA with AMC-CSMA with spatial reuse transmissions, Cross layer power-rate control scheme

Module:5	Network Layer Design	6 hours

Routing in Mobile Ad Hoc Networks-Features of routing in cognitive radio networks (CRN), Dynamic source routing in MANET, Ad-hoc on-demand distance vector (AODV), Routing in CRN-Routing of dynamic and unidirectional cognitive radio links

in CRN, Control of CRN-Flow control and end-to-end error control, Network tomography, Self-Organized CRNs.		
Module:6	**Trusted Cognitive Radio Networks**	**6 hours**
Framework of Trust in CRN, Trusted Association and Routing, Trust with Learning-Modified Bayesian learning, Learning experiments for CRN, Security in CRN-Dilemma of CRN security, Requirements and challenges for preserving user privacy in CRNs, Implementation of CRN security.		
Module:7	**Spectrum Management**	**4 hours**
Spectrum Sharing, Spectrum Pricing, Mobility Management of Heterogeneous Wireless Networks, Regulatory Issues and International Standards		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours	**45 hours**

Text Book(s)	
1.	Ahmed Khattab, Dmitri Perkins, Magdy Bayoumi, Cognitive Radio Networks, Springer New York, NY, 2013.
Reference Books	
1.	Setoodeh, P., & Haykin, S. (2017). Fundamentals of cognitive radio. John Wiley & Sons.
2.	Alexander M. Wyglinski, Maziar Nekovee, Thomas Hou, Cognitive Radio Communications and Networks, Academic Press, Elsevier, 2010.
3.	Xiao, Y., & Hu, F. (Eds.). (2019). Cognitive radio networks. CRC press.
4.	Ezio Biglieri, Andrea J. Goldsmith, Larry J. Greenstein, Narayan B. Mandayam, H. Vincent Poor, “Principles of Cognitive Radio”, Cambridge, 2012

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test

Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE406E	FPGA Based System Design	2	0	2	3
Pre-requisite	BECE102L, BECE102P	Syllabus version			
		1.0			

Course Objectives

1. Understand FPGA Architecture and technologies
2. Modeling of complex digital sub-systems
3. Implementation of complex FPGA applications in real world scenario

Course Outcomes

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

1. Understand architectures of programmable logic devices
2. Understand various abstraction level in Verilog HDL
3. Construct high speed arithmetic and memory circuits
4. Analyze the synthesis and timing constraints/reports
5. Design the system using soft core processors
6. Develop the FPGA based system for various applications in signal processing
7. Develop and prototype digital systems using FPGA

Module:1	**Programmable Logic Devices**	**4 hours**

Types of Programmable Logic Devices: PLA, PAL, CPLD - FPGA Architecture – Programming Technologies-Chip I/O- Programmable Logic Blocks- Fabric and Architecture of FPGA.

Module:2	**HDL Fundamentals**	**3 hours**

Verilog Behavioral, Data Flow and Structural Modeling, Useful Modeling Techniques.

Module:3	**Implementation of Arithmetic system**	**5 hours**

Arithmetic Circuits: High Speed Adders, Carry look-ahead adder, Carry save adders, Conditional Sum adders, Sequential and Parallel Multipliers

Module:4	**FSM and memory modelling**	**5 hours**

Synchronous and Asynchronous FIFO – Single port and Dual port ROM and RAM - FSM Verilog modeling of Sequence detector - Serial adder - Vending machine.

Module:5	**Synthesis and Timing Analysis**	**3 hours**

Synthesis, Optimization of Speed: Introduction, Strategies for Timing Improvement; Optimization of Area, Optimization of power

Module:6	**SoC Design**	**4 hours**

Introduction to hardware – software codesign, Introduction to Qsys and Intel Quartus prime tool, Nios II Software Build Tools for Eclipse, Incorporate custom peripherals & instructions into an embedded system.

Module:7	**FPGA Applications**	**4 hours**

Embedded system design using FPGAs, DSP using FPGAs, Dynamic architecture using FPGAs, reconfigurable systems, application case studies. Simulation / implementation exercises of combinational, sequential and DSP kernels on Xilinx / Altera boards.

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	Michael D Ciletti, Advanced Digital Design with the Verilog HDL, Prentice Hall, Second Edition, 2017.			
Reference Books				
1.	Charles H Roth Jr, Lizy Kurian John and ByeongKil Lee Digital Systems Design using Verilog, Cengage Learning, First Edition, 2016.			
2.	Wayne Wolf, FPGA Based System Design, Prentices Hall Modern Semiconductor Design Series, 2011.			
3.	Ming-Bo Lin, Digital Systems Design and Practice: Using Verilog HDL and FPGAs, Create Space Independent Publishing Platform, Second Edition, 2015.			
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test				
Indicative Experiments				
1.	Design of adders and Multipliers			**6 hours**
2.	Design of FSM			**6 hours**
3.	Design of Memory circuits			**6 hours**
4.	Synthesis and Timing Analysis			**6 hours**
5.	System design using Qsys			**6 hours**
	Total Laboratory Hours			**30 hours**
Mode of assessment: Continuous assessment and FAT				
Recommended by Board of Studies	28-02-2023			
Approved by Academic Council	No. 69	Date	16-03-2023	

Course Code	Course Title	L	T	P	C
BECE407E	ASIC Design	2	0	2	3
Pre-requisite	BECE303L, BECE303P	Syllabus version			
	`	1.0			

Course Objectives

1. Explain the HDL coding guidelines, synthesizable HDL constructs and RTL synthesis Flow with respect to different cost functions.
2. Teach how to perform Static Timing Analysis for ASIC design.
3. Discuss the guidelines at each abstraction level in physical design
4. Provide detailed insight on importance of physical design verification

Course Outcomes

At the end of the course the student will be able to

1. Design a digital system by adhering to synthesizable HDL constructs.
2. Synthesize the given design by considering various constraints and to optimize the same.
3. Understand various timing parameters and perform Static Timing Analysis for ASIC design
4. Perform physical design by adhering to guidelines.
5. Apprehend the importance of physical design verification.
6. Design ASIC based systems using industry standard tools.

Module:1	**ASIC Design Methodology & Design Flow**	**3 hours**

Implementation Strategies for Digital ICs: Custom IC Design- Cell-based Design Methodology - Array based implementation approaches - Traditional and Physical Compiler based ASIC Flow.

Module:2	**Verilog HDL Coding Style for Synthesis**	**6 hours**

HDL Coding style – Guidelines and Recommendation - FSM Coding Guideline and Coding Style for Synthesis. Datapath and Control Logic Design.

Module:3	**RTL Synthesis**	**3 hours**

RTL synthesis Flow – Synthesis Design Environment & Constraints – Architecture of Logic Synthesizer - Technology Library Basics– Components of Technology Library –Synthesis Optimization- Technology independent and Technology dependent synthesis- Data path Synthesis – Low Power Synthesis - Formal Verification.

Module:4	**Basic Timing Analysis**	**4 hours**

Timing Parameter Definition – Setup Timing Check- Hold Timing Check- Multicycle Paths- Half-Cycle Paths- False Paths

Module:5	**Advanced Timing Analysis**	**5 hours**

Clock skew optimization – On-Chip Variations- AOCV-Time Borrowing- Setup and Hold Violation Fixing.

Module:6	**Physical Design**	**5 hours**

Detailed steps in Physical Design Flow- Guidelines for Floor plan, Placement, CTS and routing– ECO flow – Signal Integrity Issues.

Module:7	**Physical Design Verification**	**3 hours**

Timing Sign-off, Physical Verification – Signoff DRC and LVS, ERC, IR Drop Analysis, Electro-Migration Analysis and ESD Analysis.

Module:8	**Contemporary Issues**	**1 hours**

	Total Lecture hours:	**30 hours**
Text Book(s)		
1.	Vaibbhav Taraate, ASIC Design and Synthesis RTL Design Using Verilog, Springer, First Edition, 2021, Singapore.	
Reference Books		
1.	Khosrow Golshan, PHYSICAL DESIGN ESSENTIALS An ASIC Design Implementation Perspective, First Edition, 2010.	
2.	Michael John Sebastian Smith, Application-Specific Integrated Circuits, First Edition, 2002.	
3.	J. Bhasker and Rakesh Chadha, Static Timing Analysis for Nanometer Designs, Springer, First Edition, 2010, USA.	
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test		
Indicative Experiments		
1.	Design of Digital Architecture for given specification	**6 hours**
2.	Logical Synthesis of Digital Architecture	**6 hours**
3.	Netlist Optimization and Formal Verification	**6 hours**
4.	Physical Synthesis of Digital Architecture	**6 hours**
5.	Physical Verification of digital architecture	**6 hours**
	Total Laboratory Hours	**30 hours**
Mode of assessment: Continuous assessment and FAT		
Recommended by Board of Studies	28-02-2023	
Approved by Academic Council	No. 69	Date 16-03-2023

Course Code	Course Title	L	T	P	C
BECE408L	Microwave Integrated Circuits	3	0	0	3
Pre-requisite	BECE305L, BECE305P	Syllabus version			
		1.0			

Course Objectives

1. To have the essential knowledge of various planar microstrip circuits
2. To design and analyse various types of microwave planar circuits
3. To acquaint the fabrication techniques and tolerances for MIC circuits

Course Outcomes

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

1. Comprehend the importance of various microstrip lines and the losses due to various microstrip discontinuities
2. Design the lumped elements for microwave circuits
3. Analyze various microstrip resonators
4. Design and analyze band pass filters
5. Design the various microwave amplifiers, oscillators and mixers
6. Evaluate the performance of various fabrication techniques for planar circuits

Module:1	Planar transmission lines	6 hours

Introduction, types of MICs and their technology; Microstrip lines, strip lines, slotted lines, co-planar waveguides, coupled lines and SIW. Losses in microstrip transmission lines.

Module:2	Passive elements for MICs and discontinuities	8 hours

Lumped microstrip components: Design of microstrip and chip inductors, capacitors, resistors, Quasi lumped microstrip elements: Open and short circuited stubs (quarter wavelength, half wavelength). Interdigital capacitors, Approximate analysis. Discontinuities: Corners, symmetrical step, T-junction and series gaps

Module:3	Microstrip Resonators	6 hours

Analysis and Design of Quarter & Half wave length resonators, Ring resonators, Patch resonators and Slot resonators.

Module:4	Microwave Filter Design	7 hours

Introduction, Band pass filter: Insertion loss method, Conversion from low pass to band pass, Design of band pass filter using lumped elements, distributed elements, impedance inverters and coupled line filters.

Module:5	Microwave Amplifiers	6 hours

Single stage amplifier design for maximum and specific gain, Noise figure, Design of low noise amplifiers, Gain compression, Intermodulation distortion, third order intercept point, dynamic range.

Module:6	Microwave Oscillators and Mixers	5 hours

Conditions for oscillations, one port oscillator, two port oscillator (Transistor oscillators), Characteristics of mixer, Single ended diode mixer, Single ended FET mixer and Image reject mixer.

Module:7	MIC and MMIC Fabrication Technologies	5 hours

Hybrid MICs, Configuration, Dielectric substances, thick and thin film technology, LTCC, HTCC, Printed Circuit Board (PCB) Technology, Fabrication process of MMIC

Module:8	Contemporary Issues	2 hours

	Total Lecture hours:	**45 hours**
Text Book(s)		
1.	TC Edwards,MB Steer ,Foundations for Microstrip circuit design, 4e, 2016, John Wiley, UK	
Reference Books		
1.	Ali A Behagi, RF and Microwave Circuit Design: A Design Approach using ADS, 2017, 1e, Techno Search, India.	
2.	D. M. Pozar, Microwave engineering, 2020, 4e, John Wiley, India.	
3.	G Gonzalez, Microwave transistor amplifiers, 1997, 2e, PHI Inc., NJ	
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test		
Recommended by Board of Studies	28-02-2023	
Approved by Academic Council	No. 69	Date 16-03-2023

Course Code	Course Title	L	T	P	C
BECE409E	Sensors Technology	2	0	2	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To attain a broad familiarity with the principle of sensing and different sensors for real world applications
2. Study the various sensor technologies for the measurement of physical quantities and develop suitable signal conditioning circuits.
3. Identify most suitable sensors for each measurement application and get acquainted with fabrication and interfacing process

Course Outcomes

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

1. Understand the sensors, sensor materials and sensor technologies.
2. Utilize various RLC and self-generating sensors for measuring physical quantities
3. Design appropriate signal conditioning and compensating circuits for RLC sensors
4. Fabricate various sensors using different fabrication techniques
5. Explore advanced sensing mechanisms.
6. Explore smart sensors and IOT for various sensor applications
7. Integrate the various sensors, work with them and interpret the data obtained from various applications.

Module:1	Sensing Mechanism	4 hours

Principles of Sensing: Resistive, Capacitive, Magnetic, Inductive, Piezoelectric, Piezo-resistance, Pyro-electric, Hall effect, RF sensing. Sensor materials and material properties. Sensor Technologies: Micro Technology, Micro-Electro-Mechanical Systems Technology, Nanotechnology. Example of Smart Sensors in Nature (Vision, Hearing, Touch, and Smell).

Module:2	RLC and Self Generating Sensors	4 hours

Resistive Sensors – Strain Gauges, Resistance Temperature Detectors, Thermistors, Light dependent resistors, Self and Mutual Inductive Transducers, LVDT, Capacitive Transducers, Variable Distance, Variable Area, Variable Dielectric Type Capacitive Sensors. Self-Generating Sensors – Thermoelectric Sensors, Piezoelectric Sensors, Pyroelectric sensors, Photovoltaic sensors, Electrochemical Sensors.

Module:3	Sensor Signal Conditioning	4 hours

DC Bridges for Resistance Measurements-Wheatstone Bridge, Kelvin Bridge. AC Bridges for Capacitance and Inductance Measurements-AC Bridge, Schering Bridge. Sensor Compensation Circuits-Temperature, Non-linearity and Offset Compensation.

Module:4	Sensor Fabrication	4 hours

Thick and Thin Film Sensor Fabrication – Screen Printing Technology, PVD, CVD, Fabrication of MEMS and NEMS Sensors – Lithography, Micromachining Techniques

Module:5	Advanced Sensors	4 hours

Position Encoders, Resonant Sensors, Sensors Based on Semiconductor Junctions, Fiber-Optic Sensors, Ultrasonic-Based Sensors, Biosensors, Superconducting Quantum Interference Devices (SQUIDs).		
Module:6	**Smart Sensors**	**4 hours**
Smart Transducers: Smart Sensors, Components of Smart Sensors, General Architecture of Smart Sensors, Evolution of Smart Sensors, Advantages, Application area of Smart Sensors.		
Module:7	**Sensors for IoT**	**4 hours**
Sensor-Cloud; Fog Computing, Smart Cities and Smart Homes, Connected Vehicles, Smart Grid, Industrial IoT, Case Study: Agriculture, Healthcare, Activity Monitoring		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Winncy Y. Du, "Resistive, Capacitive, Inductive, and Magnetic Sensor Technologies", 2019, 1st Edition, CRC press, London.
2.	B. C. Nakra and K. K. Chaudhary, "Instrumentation, Measurement and Analysis", 2016, 4th Edition, McGraw Hill Education India Private Limited.
Reference Books	
1.	A.K. Sawhney, "A Course in Electronic Measurements and Instrumentation", 2015, Dhanpat Rai & Co. (P) Limited.
2.	Ramón Pallás-Areny and John G. Webster, "Sensors and Signal Conditioning" 2012, 2nd Edition, John Wiley and Sons, Inc.
3.	Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press, 2017.
4.	Nihtianov, Stoyan, and Antonio Luque, eds. Smart sensors and MEMS: Intelligent sensing devices and microsystems for industrial applications. Woodhead Publishing, 2018.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test

List of Experiments		
1	Characteristics of Thermistor	**2 hours**
2	Characteristics of Strain Gauge	**2 hours**
3	Characteristics of Light Dependent Resistor	**2 hours**
4	Characteristics of Resistance Temperature Detector	**2 hours**
5	Characteristics of Angular potentiometer transducer model.	**2 hours**
6	Characteristics of LVDT	**2 hours**
7	Characteristics of Capacitive Level Sensor	**2 hours**
8	Characteristics of Thermocouples	**2 hours**
9	Characteristics of Photoelectric Tachometer	**2 hours**
10	Calibration of RTD and signal conditioning of RTD	**2 hours**
11	Calibration of Thermistor and signal conditioning of thermistor	**2 hours**
12	Characteristics of piezoelectric and Hall effect sensors	**2 hours**

13	Simulation of Biosensors/Chemical Sensors	**2 hours**
14	Simulation and design of sensors using MATLAB/LABVIEW/ COMSOL	**2 hours**
15	PC based Data acquisition system.	**2 hours**
	Total Laboratory Hours	**30 hours**
Mode of assessment: Continuous assessment &Final Assessment Test (FAT)		
Recommended by Board of Studies	28-02-2023	
Approved by Academic Council	No. 69	Date 16-03-2023

Course Code	Course Title	L	T	P	C
BECE208E	Data Structures and Algorithms	2	0	2	3
Pre-requisite	BCSE101E	Syllabus version			
		1.0			

Course Objectives

1. To emphasize the scope and significance of Data Structures and Algorithms for real world problems.
2. To enable a good understanding of the fundamental data structures.
3. To enable a study of algorithms for various kinds of applications.
4. To impart skill to theoretically analyze and evaluate performance of algorithms

Course Outcome

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

1. Identify a suitable data structure technique that can solve a given problem.
2. Design an efficient algorithm for a given problem statement. For given problem develop algorithms and theoretically analyze the efficiency.
3. Develop efficient algorithms for handling different formats of data like text, numbers etc.
4. Learn the systematic way of organizing large amounts of data.
5. Correlate and map real word problems to algorithmic solutions.
6. Provide efficient algorithmic solution for real-world problems.

Module:1	Implementing Data Structures	5 hours

Linked list, Stack, Queues, Trees, Maps, Hash Tables.

Module:2	Algorithm Analysis	3 hours

Analysis Algorithms - Asymptotic notations – Recurrences -Substitution - Recursion-tree – The master method

Module:3	Algorithms with Numbers	3 hours

Sorting and Searching- Insertion sort, Binary Search, Divide and Conquer algorithms-Merge sort, Quick Sort.

Module:4	Algorithms on Strings	4 hours

Pattern Matching- KMP, Rabin-karp algorithm, Huffman Encoding.

Module:5	Graph Algorithms	5 hours

Decomposition of graphs, Paths in graphs: BFS & DFS, Minimum Spaiining Algorithms: Prim's & Kruskals's - Single-Source (Dijktra's) & All-pairs (Floyd & Warshal's).

Module:6	Algorithms for Optimization	5 hours

Brute force, Dynamic programming, Greedy algorithms: Fractional Knapsack & Linear programming.

Module:7	Search Heuristics	3 hours

Introduction to NP Completeness, Search Heuristics, Intelligent exhaustive search, Local search heuristics.

Module:8	Contemporary issues	2 hours

	Total Lecture hours:	30 hours

Text Book(s)		
1.	Introduction to Algorithms, Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, MIT Press, Fourth edition ,2022	
2.	Mark A. Weiss, Data Structures & Algorithm Analysis in C++, 4th Edition, 2013, Pearson Education.	
Reference Books		
1.	Michael T Goodrich, Roberto Tamassia & Michael H Goldwasser, Data Structures and Algorithms in Java, Wiley 2014.	
2.	Kent. D. Lee, Steve Hubbard, Data Structures and Algorithms with Python, Springer, 2015.	
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test		
Indicative Experiments		
1.	Implementing Linked list - Stacks & Queues, Trees, Maps & Hash Tables by demonstrating applications for each.	**12 hours**
2.	Performance evaluation of Divide and Conquer Algorithms	**4 hours**
3.	Text Processing - Compression & Encryption	**4 hours**
4.	Implementing Graph Algorithms	**3 hours**
5.	Implementation of Algorithms: Dynamic Programming, Greedy & Linear Programming	**3 hours**
6.	Search Algorithms	**4 hours**
	Total Laboratory Hours	**30 hours**
Mode of Assessment: Continuous Assessment and Final Assessment Test		
Recommended by Board of Studies	14-05-2022	
Approved by Academic Council	No. 66	Date 16-06-2022

Course Code	Course Title	L	T	P	C
BECE209E	Structured and Object Oriented Programming	2	0	4	4
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives:

1. To summarize the usefulness of branching and looping statements in one dimension and multi-dimensional array programming.
2. To equip students with dynamic memory management through an expertise on pointers.
3. To introduce students the importance of polymorphism and inheritance in an object oriented programming.
4. To teach students the way of supervising exceptions through exception handlers and files through file handlers.

Course Outcomes:

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

1. Implement branching and looping statements to handle 1D and 2D arrays.
2. Realize the importance of pointers to manage the memory dynamically.
3. Comprehend the use of structures and unions to encapsulate different data types in programming.
4. Apply polymorphism and inheritance which are imbibed in object oriented programming.
5. Infer and handle different exceptions.
6. Access files in terms reading and writing through various file handlers.
7. Comprehend various elements of object-oriented programing paradigm and propose solutions through inheritance and polymorphism.

Module:1	C Programming Fundamentals, Arrays and Strings	4 hours

Variables - Reserved words, Data Types, Operators, Operator Precedence - Expressions - Type Conversions - I/O statements - Branching and Looping: if, if-else, nested if, if-else ladder, switch statement, goto statement - Loops: for, while and do...while, break and continue statements. Arrays: One Dimensional array - Two-Dimensional Array — Strings and its operations.

Module:2	Functions and Pointers	4 hours

User Defined Functions: Declaration — Definition — call by value and call by reference - Types of Functions - Recursive functions - Storage Classes - Scope, Visibility and Lifetime of Variables. Declaration and Access of Pointer Variables, Pointer arithmetic — Dynamic memory allocation — Pointers and arrays - Pointers and functions.

Module:3	Structures and Unions	3 hours

Declaration, Initialization, Access of Structure Variables - Arrays of Structure - Arrays within Structure - Structure within Structures - Structures and Functions — Pointers to Structure.

Module:4	Overview of Object-Oriented Programming	6 hours

Features of OOP - Classes and Objects - “this” pointer - Constructors and Destructors - Static Data Members, Static Member Functions and Objects - Inline Functions — Call by reference - Functions with default Arguments - Functions with Objects as Arguments - Friend Functions and Friend Classes. Dynamic Memory Allocation.

Module:5	Inheritance and Polymorphism	6 hours

Inheritance - Types of Inheritance: Single inheritance, Multiple Inheritance, Multi-level Inheritance, Hierarchical Inheritance - Multipath Inheritance - Inheritance and constructors

Module:6	**Generic Programming**	**4 hours**
Function templates and class templates, Standard Template Library.		
Module:7	**Exception handling and files**	**3 hours**
Introduction to exceptions, Try and catch blocks, throw statement, File handling functions. Sequential and Random access.		
	Total Lecture hours:	**30 hours**

Text Book	
1	Herbert Schildt, C: The Complete Reference, 2017, 4th Edition, McGraw Hill Education.
2	Herbert Schildt, C++: The Complete Reference, 2017, 4th Edition, McGraw Hill Education.
Reference Books	
1	Yashavant Kanetkar, Let Us C: 2020, 17th Edition, BPB Publications, 2020.
2	Stanley Lippman and Josee Lajoie, C++ Primer, 2012, 5th Edition, Addison-Wesley publishers
3	Byron S Gottfried, Programming with C, 2018, 2018, 4th Edition, Schaum's outline series.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test

Indicative Experiments	
1.	Programs using basic control structures, branching and looping
2.	Experiment the use of 1-D, 2-D arrays and strings and Functions
3.	Demonstrate the application of pointers
4.	Experiment structures and unions
5.	Programs on basic Object-Oriented Programming constructs.
6.	Demonstrate various categories of inheritance
7.	Program to apply kinds of polymorphism.
8.	Develop generic templates and Standard Template Libraries.
9.	Demonstrate the use of Exception handling.
10.	Demonstrate the working of file handling.

Total Hours	**60 hours**

Mode of Assessment: Continuous Assessment and Final Assessment Test

Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE309L	Artificial Intelligence and Machine Learning	3	0	0	3
Pre-requisite	BMAT201L	Syllabus version			
		1.0			

Course Objectives

1. To get acquainted with different types of intelligent agents.
2. To understand the importance and significance of Machine learning.
3. To preface the essentials of Deep Learning.

Course Outcome

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

1. Comprehend different intelligent agents and its variants.
2. Solve the real-world problem using the various search algorithms.
3. Infuse various symbolic knowledge representation.
4. Employ intelligent agents for decision making.
5. Handle real-time issues using various learning methodologies.
6. Apply deep learning algorithms for solving real-world problems.

Module:1	**Foundations of AI**	**4 hours**

Introduction – Agents and rationality – Task environment – Agent Architecture Types.

Module:2	**Problem-solving by Searching**	**7 hours**

Search Space – Search algorithms, strategies – Search in complex environments.

Module:3	**Knowledge Representation**	**6 hours**

Knowledge-based agents, Agents based on Propositional Logic – First-order logic.

Module:4	**Probability reasoning and uncertainty**	**6 hours**

Quantifying uncertainty, Knowledge representation in uncertainty, Decision making – Simple, complex.

Module:5	**Data Preparation for Machine Learning**	**4 hours**

Basics of Vectors & Matrices – Overview: Data Cleaning, Integration, Transformation & Reduction.

Module:6	**Learning from Examples**	**9 hours**

Forms of Learning – Dimensionality reduction - Regression – Statistical Methods: Naïve-Bayes, Nearest Neighbor, Decision Trees – Random Forest, Clustering, Ensemble Learning, Case studies – Machine Learning in Signal Processing, Intelligent Antenna.

Module:7	**Deep Learning**	**7 hours**

Simple Feed Forward Networks – Computational graphs for Deep Learning – Convolutional Networks – Recurrent Neural Networks – Kernel Machines – Hidden Markov Models.

Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1. Stuart J Russell, Peter Norwig, Artificial Intelligence – A modern approach, 2015, 3rd edition, Pearson, India.

Reference Books

1. Vinod Chandra S.S, Anand Hareendran S., Artificial Intelligence: Principles and

	Applications, 2020, 2nd Edition, PHI Learning Pvt. Ltd., India.		
2.	Alpaydin ethem, Introduction to Machine Learning, 2019, 3rd edition, PHI Learning Pvt. Ltd., India.		
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	14-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
BECE310L	Satellite Communications	3	0	0	3
Pre-requisite	BECE306L, BECE306P	Syllabus version			
		1.0			

Course Objectives

1. To learn the conceptual knowledge of communication through satellites.
2. To provide a detailed understanding of navigation - both inertial and by navigation satellites.
3. To analyze typical challenges of satellite based systems.

Course Outcomes

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

1. Analyse the concept of orbits, launch vehicles and satellites
2. Comprehend the design of satellite subsystems
3. Imbibe the basics of digital transmission related to satellite communication
4. Analyse the navigation satellite services.
5. Analyse the impact of diverse parameters on satellite link design
6. Apply the satellite systems for various applications

Module:1	Orbital Mechanics	6 hours

Overview of satellite communication - Orbital mechanics - Equations of the orbit - Kepler's laws of planetary motion - Orbital elements - Look angle determination - Orbital perturbation and determination

Module:2	Orbital Launchers	3 hours

Launches and launch vehicles- Launch vehicle selection factors - Satellite positioning into geostationary orbit - Orbital effects in communication systems performance - Doppler shift -Range variations - Solar eclipse and sun transit outage.

Module:3	Elements of Communication Satellite Design	5 hours

Satellite subsystems - Attitude and orbit control electronics - Telemetry and tracking - Power subsystems - Communication subsystems - Satellite antennas - Reliability and redundancy- Frequency modulation techniques.

Module:4	Digital Transmission Basics	4 hours

Modulation and Multiplexing -Multiple access techniques – FDMA, TDMA, CDMA, SDMA, ALOHA and its types – Onboard processing- Satellite switched TDMA – Spread spectrum transmission and reception for satellite networks.

Module:5	Satellite Link Design	9 hours

Basic transmission theory – System noise temperature and G/T Ratio- Noise figure and noise temperature- Calculation of system noise temperature – G/T ratio for earth stations - Link budgets - Uplink and downlink budget calculations - Error control for digital satellite links - Prediction of rain attenuation and propagation impairment counter measures.

Module:6	VSAT and NGSO System	7 hours

Overview of VSAT systems-VSAT Network Architectures, One Way Implementation, Two-Way Implementation, Delay Considerations, VSAT Earth Station Engineering -NGSO Satellite Systems Constellation/ Constellation Design Considerations - Starlink, One Web

Module:7	Direct Broadcast Satellite Television systems and GPS	9 hours

DBS Satellite Systems: DVB-S2X Standards -System Design for High-Throughput Applications , Antenna Considerations, Modulation Scheme Considerations, Error Coding Considerations, Remote Sensing Application, Navigation Satellite Systems GPS-Position Calculations and Accuracy, Navigation Messages, Receiver Design,- IRNSS		
Module:8	**Contemporary Issues**	**2 hours**
Lecture hours:	**Total**	**45 hours**

Text Book(s)	
1.	Pratt, C.W. Boastian and Jeremy Allnutt “Satellite Communication”, 2018, 2nd edition, John Wiley and Sons, Bangalore, India.
Reference Books	
1.	D.Roddy, “Satellite Communications”, 2011, 4th edition (sixth reprint), Tata McGraw Hill, New York.
2.	Anil K. Maini, Varsha Agrawal, “Satellite Communications”, 2018, Wiley India Pvt. Ltd, New Delhi, India
3	G. Maral, M. Bousquet, Z. Sun, “Satellite Communications Systems: Systems, Techniques and Technology”, 2020 (6th Edition), John Willy and sons, New York.
4	Teresa M. Braun ,”Satellite Communications Payload and System”, 2021, 2nd edition, John Wiley and Sons, USA
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test	

Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE311L	Radar Systems	3	0	0	3
Pre-requisite	BECE305L, BECE305P	Syllabus version			
		1.0			

Course Objectives

1. To understand and analyze various radar parameters.
2. To analyze and design transmitter, receiver circuits and antennas for various radars.
3. To understand and contrast the need for modern radars for different applications.

Course Outcomes

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

1. Analyze the radar range equation and radar cross section.
2. Analyze radar parameters to design and conduct radar experiments.
3. Evaluate the performance of transmitter and receiver circuits.
4. Realize various signal and data processing steps involved in the recovery of a signal.
5. Analyze and design antennas for different radars.
6. Distinguish modern radars for diverse applications.

Module:1	**Principles of Radar**	**6 hours**

Introduction to Radars, Radar principle, Doppler Effect, Radar frequency bands, Radar Block Diagram, Radar Range Equation, Radar Cross section of targets, Radar Clutter, types of scattering, Applications of Radars

Module:2	**Radar Parameters**	**6 hours**

Transmit pulse width, Pulse Repetition Frequency, baud length, range resolution, unambiguous range, coherent integration, FFT points, incoherent integration, detectability, SNR, receiver bandwidth, Transmit power, Pulse compression techniques.

Module:3	**Transmit and Receive modules(TRM)**	**8 hours**

Block schematic, Timing and signal generation for TRM operation, Gain and phase control, Design of power amplifiers, Transmit-receive switch, circulator, blanking switch, types of amplifiers (linear amplifiers, low noise amplifiers and solid-state amplifiers), and band pass filter.

Module:4	**Signal & Data Processing**	**6 hours**

Digital receiver and signal processing steps, DC and clutter removing, spectrum cleaning, computation of spectral moments, computation of velocity, range time intensity (SNR) computation, cross correlation and autocorrelation, capon imaging, maximum entropy method for imaging.

Module:5	**Radar Antennas**	**8 hours**

Antenna parameters for Radars, Parabolic Reflector antenna, Yagi-Uda antenna, Microstrip patch antenna, Phased array system: Planar Arrays, Electronic beam steering, Beam forming, Phase Shifters, Active Phased array and Semi active phased array system, Radomes.

Module:6	**Types of Radars**	**6 hours**

Principle of operation, Block diagram, Advantages, limitations and Application of CW Radar, Pulsed Radar, MTI Radar, Synthetic Aperture Radar, and Meteorological Radars(MST and Doppler weather radar).

Module:7	**Stealth Technology**	**3 hours**

Principles, Radar cross section reduction, RF absorbers and Radar stealth countermeasures and limits.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Merrill Skolnik, Introduction to Radar Systems, 3rd Edition, McGraw-Hill, USA, 2017.
Reference Books	
1.	Habibur Rahman, Fundamental Principles of Radar, CRC Press, Taylor & Francis Group, USA, 2019.
2.	Merrill Skolnik, Radar Handbook, 3rd Edition, McGraw-Hill, USA, 2008
3.	Mark A. Richards, James A. Scheer, William A. Holm (Editors), Principles of Modern Radar Vol. I: Basic Principles, SciTech Publishing, Inc, USA, 2016.
4.	G.S.N. Raju, Radar engineering and fundamentals of navigational aids, DreamTech Press (Wiley distribution), New Delhi, India, 2019.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test

Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE312L	Robotics and Automation	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To provide basic understanding of robotics and automation.
2. To demonstrate the need of various sensors and drives in robotic system.
3. To make students understand about the robotic kinematics, path planning and different trajectories.
4. To deliver the programming languages to design robots in practice and research for contemporary use.

Course Outcomes

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

1. Classify robots and summaries their role in diverse applications
2. Infer the working of basic electric, electronic, and other types of drives required in robots.
3. Distinguish and interpret the sensors for various applications in robotics and automation.
4. Determine the mathematical model of robotic systems and analyze their kinematic behavior.
5. Design robots for varied working environments encompassing all types of motions across different paths and diverse trajectories.
6. Apply the ideas in performing various robotic tasks for contemporary industry standards using suitable programming skills.

Module:1	Robotics and Automation	5 hours

Robots: Basics, Types-Application, Mobility, D o F , Terrain, components classification, performance characteristics, Industrial Robots, HRI, Automatic assembly system.

Module:2	Drives for Robotics	5 hours

Drives: Electric, hydraulic and pneumatic drives.

Module:3	Sensors for Robots	7 hours

Tactile sensors - Proximity and range sensors – Optical Sensor- limit switch sensor- surface array sensor- Acoustic sensors - Vision sensor systems – Vision feedback system -Image processing and analysis - Image data reduction – Segmentation – Feature extraction -Object recognition.

Module:4	Robot Kinematics and Dynamics	10 hours

Kinematics of manipulators, rotational, translation and transformation Homogeneous, Transformations, Denavat – Hartenberg Representation, Inverse Kinematics. Linearization of Robot Dynamics – State variable continuous and discrete models.

Module:5	Path Planning	5 hours

Types of trajectories, trajectory planning and avoidance of obstacles, path planning, skew motion, joint integrated motion and straight line motion.

Module:6	Programming of Robots	5 hours

Robot programming: ROS1 and ROS2, languages and software packages- MATLAB/Simulink, OpenRDK, Adams.

Module:7	Application of Robots	6 hours

Industrial robots used for welding, painting and assembly, remote controlled robots, robots for nuclear, thermal and chemical plants, industrial automation, typical examples of automated Industries, Humanoid robots, medical robots, under water robots, drones.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Kevin M. Lynch, Frank C. Park, "Modern Robotics- Mechanics, Planning, and Control", 2017, Cambridge University Press.
Reference Books	
1.	R. K. Mittal, I. J. Nagrath, "Robotics and Control", 2017, McGraw Hill Education, India,
2.	Ramkumar Gandhinathan, Lentin Joseph, "ROS Robotics Projects-Build and Control Robots Powered by the Robot Operating System, Machine Learning, and Virtual Reality", 2019, Packt Publishing.
3.	Hutchinson, S., Spong, M. W., Vidyasagar, M. "Robot Modeling and Control", 2020, Wiley publications, United Kingdom.
4.	Pawlak, A. M. Sensors and Actuators in Mechatronics: Design and Applications, 2017, CRC Press, United Kingdom.
5.	Lentin Joseph, "Robot Operating System (ROS) for Absolute Beginners - Robotics Programming Made Easy, 2018, Apress.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test

Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE313L	Information Theory and Coding	3	0	0	3
Pre-requisite	BECE306L, BECE306P	Syllabus version			
		1.0			

Course Objectives

1. This course provides an understanding of fundamental information theoretic techniques including applications to compression and error control coding.
2. It also aims at quantitative measure of information may be used in order to build efficient solutions to multitudinous engineering problems.

Course Outcomes

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

1. Analyze probability theory and evaluate the average and mutual information.
2. Examine different types of channels and determine their capacity.
3. Implement various types of source coding algorithms and analyze their performance.
4. Apply various types of coding techniques and standards on audio and video.
5. Design linear block codes and cyclic codes (encoding and decoding).
6. Design and build the channel coder for 5G standard.

Module:1	Information Measures	7 hours

Review of Probability Theory, Introduction to information theory, Uncertainty, self-information, average information, Marginal Entropy, Joint Entropy and Conditional Entropy, Mutual Information, Relationship between entropy and mutual information and their properties, Markov statistical model for information source, Entropy and information rate of markov source , Information measures of continuous random variables.

Module:2	Channel Models and Capacity	6 hours

Importance and types of various channel models - Channel capacity calculation – Binary symmetric channel, binary erasure channel - Shannon's channel capacity and channel coding theorem - Shannon's limit.

Module:3	Probability based Source Coding	6 hours

Source coding theorem - Huffman coding - Non binary Huffman codes - Adaptive Huffman coding - Shannon Fano Elias coding - Non binary Shannon Fano codes, Arithmetic coding

Module:4	Non Probability based Source Coding	5 hours

Lempel-Ziv coding, Run-length encoding and rate distortion function - Transform coding - JPEG and JPEG 2000.

Module:5	Audio and Video Coding	5 hours

Audio Coding: types – Linear Predictive Coding (LPC) – Code Excited LPC – Perceptual Coding - MPEG Audio Coding. Video Coding: Motion Estimation and Compensation – Types of Frames – Encoding and Decoding of Frames – Video Coding Standard: MPEG 4.

Module:6	Channel Coding	9 hours

Introduction to Error control codes - Block codes, linear block codes, cyclic codes and their properties, Encoder and Decoder design- serial and parallel concatenated block code, Convolution Codes- Properties, Encoder-Tree diagram, Trellis

diagram, state diagram, transfer function of convolutional codes, Viterbi Decoding, Trellis coding, Reed Solomon codes, Turbo coder, Iterative Turbo decoder		
Module:7	**Channel Coding for 5G standard**	**5 hours**
Low Density Parity Check code - LDPC code construction, construction in 5G standard, encoding of LDPC codes, Message passing decoding on Tanner graph. Polar code – Representation, generator matrix, Successive cancellation decoder for polar codes.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1	Simon Haykin, “Communication Systems”, 2017, 5th Edition, Wiley India Pvt Ltd, India.
2	Khalid Sayood, “Introduction to Data Compression, 5th Edition, The Moragan Kaufmann Series in Multimedia Information and Systems, Elsevier, 2017.
Reference Books	
1.	Ranjan Bose, “Information Theory, Coding and Cryptography”, 2015, 1st Edition, McGraw Hill Education (India) Pvt. Ltd., India.
2	Murlidhar Kulkarni, K.S. Shivaprakasha, “Information Theory and Coding As per AICTE”, 2019, 2nd Edition, Wiley India Pvt Ltd, India.
3	Orhan Gazi, “Polar Codes: A Non-Trivial Approach to Channel Coding”, 2019, 1st Edition, Springer Topics in Signal Processing Book 15.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE314L	Electromagnetic Interference and Compatibility	2	1	0	3
Prerequisite	BECE205L	Syllabus Version			
		1.0			

Course Objectives

1. To understand importance of EMC and EMC compliance for the products.
2. To understand guidelines for reduced EMI in PCB design
3. To learn the EMI sources, mitigation, and measurement techniques/standards to guarantee the correct working modalities.

Course Outcomes

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

1. Understand the concepts related to EMI and EMC
2. Analyze the various coupling methods
3. Apply a proper EMI control technique for a specific identified EMI issue.
4. Apply the guidelines for PCB Design
5. Familiarize with EMC Measurement Techniques
6. Identify various emission and susceptibility testing standards which a product should comply with

Module 1	EMI/EMC Concepts	4 Hours

EMI/EMC definitions – Units - Sources of EMI: Classification, Lightning, ESD, NEMP - Conducted and radiated emission - Conducted and radiated susceptibility – Intra and inter system EMI - In band interference - Spectrum conservation - Radiation hazard - Specific Absorption Rate (SAR).

Module 2	EMI Coupling Principles	4 Hours

Conductive coupling: Common-mode**,** Differential-mode - Inductive coupling - Capacitive coupling - Radiative coupling

Module 3	EMI Control Techniques -I	8 Hours

Grounding: Earthing principle, Types of Grounding- system grounding - Shielding: Shielding theory and shielding effectiveness, Shielding integrity at discontinuities, Conductive coatings, Cable shielding, Bonding: Shape and material for bond strap - general guidelines for good bonds.

Module 4	EMI Control Techniques -II	8 Hours

EMI Filters: Characteristics of filters, Impedance mismatch effects, Lumped element filters, Power line filter design, Common mode filter, Differential mode filter - EMI suppression devices and components: EMI suppression cables, EMC connectors, EMC gaskets, Isolation transformers, Transient and surge suppression devices.

Module 5	EMC Design of PCBs	8 Hours

RF Sources in PCB - SMD / through hole components, Pins, Basic loops, Differential vs Common mode - Board layout: Ground plane and Power plane, ground bounce, Power distribution for two-layer boards, Power supply decoupling, Board zoning, Signal traces, Cross talk, Trace routing - Cables and connectors.

Module 6	EMI Measurements	5 Hours

Radiated interference measurements: Open area test site measurement, anechoic chamber, TEM cell; Reverberating chamber - Conducted interference measurements: Characterization of conduction currents voltages, Conducted EM noise on power supply lines, Conducted EMI from equipment - Pulsed interference immunity: ESD/EFT, Electrical surge - Time domain EMI measurement

Module 7	**EMC Standards**	**4 Hours**
Military standards, IEEE/ ANSI Standards, CISPR/IEC, FCC standards, European Standards, VDE Standards, Other EMC Standards, Company Standards, EMC compliance for wireless devices, Radio Equipment Directive (RED).		
Module 8	**Contemporary Issues**	**2 Hours**
	Total Lecture Hours	**45 Hours**
Text Books:		
1.	Clayton R.Paul, “Introduction to Electromagnetic Compatibility”, Wiley-Interscience, 2022	
Reference Books:		
1.	Henry W.Ott., “Electromagnetic Compatibility Engineering”, Wiley, 2009.	
2.	V.P.Kodali, “Engineering Electromagnetic Compatibility: Principles, Measurements, Technologies, and Computer Models”, Wiley-IEEE Press, 2001	
3.	Christos Christopoulos, “Principles and Techniques of Electromagnetic Compatibility”, CRC Press, 2007.	
4.	Mark I. Montrose, “EMC Made Simple Printed Circuit Board and System Design”, Montrose Compliance Services, 2014.	
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test		

Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE315L	Optical Networks	3	0	0	3
Pre-requisite	BECE308L, BECE308P/ BECE318L, BECE318P	Syllabus version			
		1.0			

Course Objectives

1. To introduce Optical Components, Transmission system Engineering and Optical Digital Networks.
2. To design Optical WDM Networks and to understand the routing techniques.
3. To elucidate about Optical packet switching, OTN and access networks.
4. To analyze the various optical network performances and to understand traffic management, fault management and security.

Course Outcomes

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

1. Identify the optical components and analyze the transmission system.
2. Analyze the various Optical Digital Networks
3. Design Optical WDM Networks and to understand the routing techniques.
4. Understand Optical packet switching, OTN and access networks.
5. Analyze the various optical network performance and to understand traffic management.
6. Identify the faults in optical networks and select the suitable protection techniques.

Module:1	**Optical system components**	**6 hours**

Optical System Components – Couplers, Isolators & Circulators, Multiplexers & Filters, Optical Amplifiers, Switches, Wavelength Converters; Transmission System Engineering – System model, Power penalty - transmitter, receiver, Optical amplifiers, Overall design considerations.

Module:2	**Optical digital networks**	**6 hours**

Introduction to Optical Networks; SONET / SDH, Metropolitan-Area Networks, Layered Architecture; Broadcast and Select Networks – Topologies, Media-Access Control Protocols and Testbeds; Wavelength Routing Architecture.

Module:3	**Wavelength routing networks**	**6 hours**

WDM Network Design - Cost tradeoffs, Virtual Topology Design, Routing and wavelength assignment, Statistical Dimensioning Models.

Module:4	**Packet switching and access networks**	**6 hours**

Photonic Packet Switching – OTDM, Multiplexing and De-multiplexing, Synchronization, Header Processing, Buffering, Burst Switching, Testbeds; Access Networks.

Module:5	**Optical transport network and network synchronization**	**6 hours**

Introduction- OTN Network Layers - FEC in OTN- OTN Frame Structure- OTN and DWDM- OTN Management- Synchronization - The Timing Signal- Signal Quality- Transmission Factor- Jitter and Wander- Photodetector Responsivity and Noise Contributors.

Module:6	**Network performance**	**8 hours**

Introduction-Channel Performance- Power-Bandwidth Ratio- Shannon's Limit - Optical Signal to Noise Ratio - Factors That Affect Channel Performance - Analysis of BER and SNR Related to Channel Performance - BER and SNR. **Traffic Management and Control**-Client Bandwidth Management -Wavelength Management – Paths with --Congestion Management - Routing Discovery of Optical Network -Node and Network - Wavelength Management Strategies.		
Module:7	**Network protection, fault management and security**	**5 hours**
Introduction- Fault Detection and Isolation - Fault and Service Protection - Point-to-Point Networks- Mesh Network Protection -Ring-Network - Ring-to-Ring Protection - Multi-ring Shared Protection - Network Security Issues - Definitions -Security - Security Layers in Communication Networks.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Debasish Datta, “Optical Networks”, OUP Oxford (2021), 1st Edition.
Reference Books	
1.	Biswanath Mukherjee, "Optical WDM Networks", Springer, 2006. 1st Edition.
2.	Stamatios V. Kartalopoulos "Next Generation Intelligent Optical Networks” Springer Science Business Media. LLC, 2008, 1st Edition.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test

Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No.69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE316E	Digital Image Processing	3	0	2	4
Pre-requisite	BECE301L,BECE301P	Syllabus version			
		1.0			

Course Objectives

1. To learn the fundamentals of Digital image processing in spatial and frequency domain.
2. To apply various filtering methods for image enhancement.
3. To understand the concepts of color image processing and different image compression techniques.
4. To apprehend various image segmentation algorithms and the concept of descriptors.

Course Outcomes

At the end of the course, Students will have the ability to,

1. Apply the key concepts of Digital image processing in spatial and frequency domain.
2. Compute the transform of an image by 2D-FFT, DCT, DWT and KL transform
3. Analyze the frequency domain enhancement techniques
4. Formulate the color models and to propose the desired color image processing
5. Investigate various standard image compression techniques and discriminate their effects in terms of data reduction
6. Summarize various image segmentation algorithms and to represent the same using boundary and region descriptors
7. Apply appropriate tool to implement various algorithms using the image processing concepts

Module:1	Image sampling and transformations	7 hours

Introduction, Fundamental steps in DIP – Elements of visual perception -Image sensing and Acquisition – Image Sampling and Quantization – Imaging geometry, discrete image mathematical characterization- Basic relationship between pixels. Basic Gray level Transformations – Histogram Processing – Smoothing spatial filters- Sharpening spatial filters.

Module:2	Image Transforms	7 hours

Two-dimensional Fourier Transform- Properties – Fast Fourier Transform – Inverse FFT- Discrete cosine transform and KL transform-Discrete Short time Fourier Transform. Introduction to Multiresolution analysis - Discrete Wavelet Transform- the Haar wavelet family

Module:3	Image Enhancement in Frequency domain	6 hours

Smoothing frequency domain filters- Sharpening frequency domain filters- Homomorphic filtering - Restoration filters: Bandpass – Band reject - Notch filter

Module:4	Color Image Processing	5 hours

Color models: RGB- HSI- CMYK -Pseudo color image processing- Color transformations – Smoothening and Sharpening

Module:5	Image Compression	6 hours

Overview of Image Compression Techniques- Entropy Encoding- Huffman – Arithmetic- LZW - JPEG and MPEG standards

Module:6	**Image Segmentation**	**7 hours**
Detection of discontinuities – Edge linking and boundary detection- Thresholding - Edge based segmentation - Region based segmentation- Matching- Morphological segmentation- Watershed algorithm		
Module:7	**Representation and Description**	**5 hours**
Boundary descriptors - Region descriptors - Texture descriptors - Use of Principal Components for Description.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Rafael C.Gonzalez & Richard E.Woods, "Digital Image Processing", 2017, 4th edition, Pearson Education, USA
Reference Books	
1.	Anil K.Jain, "Fundamentals of Digital Image Processing", 2015, 1st edition, Pearson India, India
2.	Mark Nixon & Alberto Aguado, "Feature Extraction, and Image Processing", 2012, 3rd edition, Elsevier's Science & Technology Publications, Woborn MA, Great Britain.
3.	Scott E Umbaugh, "Digital Image Processing and Analysis: Human and Computer Vision Applications with CVIP tools", 2011, 2nd edition, CRC press, Boca Raton, FL, USA.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test

Indicative Experiments		
1	(a) Perform point to point operation on the given image and compute the following and interpret changes in image i. Image Negative ii. Power law transformation iii. Log transformation (b) Perform contrast stretching for the given poor contrast image. (c) Perform histogram equalization for the given image and analyze the enhanced quality of the image.	**3 hours**
2	a) Read the input Image and perform Interpolation and Decimation. Show the effect of image shrinking and zooming. b) Read the input image and show the effect of gray level slicing for different levels. c) Perform Bitplane slicing for given image and comment on the number of visually significant bit planes in each image.	**3 hours**
3	Implement the following spatial domain filtering techniques for an image a) Low Pass Filtering b) High Pass Filtering c) Order Statistics (Median) Filtering	**3 hours**

4	Perform DFT for the given image and obtain its Fourier spectrum. Compute IDFT. Verify the symmetric property of DFT and compare the result with Discrete Cosine Transform (DCT).	**3 hours**
5	Removal of fine details in an image by frequency domain filtering and analysis of information loss.	**3 hours**
6	Perform image enhancement, feature extraction studies and compression using DCT.	**3 hours**
7	a) Perform image enhancement, feature extraction studies and compression using DWT. b) Perform DWT of an image, analyze and further reconstruct the image using IDWT	**3 hours**
8	Segment the region of interest from a given image using region-based segmentation and watershed algorithm.	**3 hours**
9	Identifying objects in an image based on their boundaries.	**3 hours**
10	To detect moving objects in given image frames using background subtraction algorithm.	**3 hours**
	Total Laboratory Hours	**30 hours**

Mode of assessment: Continuous assessment and FAT			
Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE320E	Embedded C Programming	2	0	2	3
Pre-requisite	NIL	Syllabus version			
		V 1.0			

Course Objectives

1. To impart logical thinking and fundamental problem-solving skills via the use of a programming language.
2. To develop basic and advanced programming concepts using C and Embedded C language.
3. To interface with microcontroller using Embedded C language.

Course Outcome

The student will be able to

1. Apply the C programming language for various data types and decision making applications.
2. Comprehend the derived data types, pointers and creation of functions.
3. Describe the architecture of 8051 microcontroller for programming & interfacing applications.
4. Write the embedded C code to 8051 for programming I/O ports, timers, serial communication, interrupt and interfacing external peripherals.
5. Develop microcontroller based applications.

Module:1	Introduction to C	3 hours

Introduction to Embedded C, difference between C and Embedded C. Introduction to C programming, comments, identifiers, variables, headers, data types, operators, order of operations, format specifies, escape sequence characters, input and output statements, programs on sequential statements.

Module:2	Control and loop statements	4 hours

Control statements: if, if-else, if-else ladder, elseif ladder, switch. Loops: do-while, while, for loops and nested loops. Break, continue, goto and exit statements. Programs on if, switch and loops.

Module:3	Arrays and strings	3 hours

Arrays: one dimensional and multi-dimensional array, programs on arrays. Strings, functions, pointers.

Module:4	Introduction to 8051 microcontroller	6 hours

Introduction to microcontroller, difference between microcontroller and microprocessor, 8051 : architecture, pin diagram of 8051, memory organization, special function registers, I/O pins ,timers, interrupts, serial interface, power consumption, external interface of the standard 8051.

Module:5	8051 programming in C	4 hours

Data types: sbit, sfr, and bit. Producing delay using loops, programming I/O ports: bit addressable and byte addressable programming, programs on sending and receiving data through I/O ports. Programs on logic operations, data conversion, data serialization with I/O ports.

Module:6	Timer and serial port programming	4 hours

Programs on accessing timers registers, programs on producing time delay using mode 1 and mode 2, programs on generating various clock frequencies, programming of timers 0 and 1 as counters. Serial port programming: transmitting and receiving data with different baud rates. Programs on timer and Serial communication interrupt.

Module:7	Interfacing with displays and sensors	4 hours

Programming of keyboard interfacing, programming of LEDs interfacing, programming of seven segment display interfacing, interfacing circuit description and programming of 16 x 2

LCD, ADC, DAC and temperature sensor interfacing.			
Module:8	**Contemporary issues**		**2 hours**
	Total Lecture hours:		**30 hours**
Text Book(s)			
1	Mike McGrath, C Programming in easy steps, 2019, 4th Edition, In Easy Steps Limited.		
2	Muhammad Ali Mazidi , Janice Gillispie Mazidi , Rolin McKinlay, 2014, The 8051 Microcontrollers & Embedded Systems , 2nd edition, Pearson.		
Reference Books			
1.	Barrett, Michaell, and Ambony Massa. Programming Embedded Systems, with C and GNU Development Tools, 2020, O'Reilly Media.		
2	Herbert Schildt, C: The Complete Reference, 2017, 4th Edition, McGraw Hill Education.		
Mode of evaluation: Internal Assessment (CAT, quizzes, Digital Assignments) & Final Assessment Test (FAT)			
Lab Component :			
Indicative Experiments			
1	Programs on Sequential statements		2 hours
2	Programs on Condition and Control statements		2 hours
3	Programs on Arrays		2 hours
4	Programs on Strings & Functions		2 hours
5	Programs on I/O ports		2 hours
6	Programs on Timer/Counter		4 hours
7	Programs on serial communication		2 hours
8	Programs on Timer Interrupts		2 hours
9	Programs on Serial Communication Interrupts		2 hours
10	Programs on External interrupts		2 hours
11	Programs on interfacing Keypad and LCDs		4 hours
12	Programs on interfacing ADC, DAC and Sensors		4 hours
	Total Laboratory Hours		**30 hours**
Mode of assessment: Continuous assessment and FAT			
Recommended by Board of Studies		07-11-2023	
Approved by Academic Council	No. XX	Date	DD-MM-YYYY

Course Code	Course Title	L	T	P	C
BECE391J	Technical Answers to Real Problems Project	0	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To gain an understanding of real-life issues faced by society.
2. To study appropriate technologies in order to find a solution to real life issues.
3. Students will design system components intended to solve a real-life issue.

Course Outcomes

1. Identify real life issue(s) faced by society.
2. Apply appropriate technologies to suggest a solution to the identified issue(s).
3. Design the related system components/processes intended to provide a solution to the identified issue(s).

Module Content **(Project Duration: Two Semesters)**

1. Students are expected to perform a survey and interact with society to find out the real life issues.
2. Logical steps with the application of appropriate technologies should be suggested to solve the identified issues.
3. Subsequently the student should design the related system components or processes which is intended to provide the solution to the identified real-life issues.

General Guidelines:

1. Identification of real-life problems
2. Field visits can be arranged by the faculty concerned
3. Maximum of 3 students can form a team (within the same/different discipline)
4. Minimum of eight hours on self-managed team activity
5. Appropriate scientific methodologies to be utilized to solve the identified issue
6. Solution should be in the form of fabrication/coding/modelling/product design/process design/relevant scientific methodology(ies)
7. Consolidated report to be submitted for assessment
8. Participation, involvement and contribution in group discussions during the contact hours will be used as the modalities for the continuous assessment of the theory component
9. Project outcome to be evaluated in terms of technical, economical, social, environmental, political and demographic feasibility
10. Contribution of each group member to be assessed

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews

Recommended by Board of Studies	12-10-2022		
Approved by Academic Council	No. 68	Date	19-12-2022

Course Code	Course Title	L	T	P	C
BECE392J	Design Project	0	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. Students will be able to upgrade a prototype to a design prototype.
2. Describe and demonstrate the techniques and skills necessary for the project.
3. Acquire knowledge and better understanding of design systems.

Course Outcomes

1. Develop new skills and demonstrate the ability to upgrade a prototype to a design prototype or working model.
2. Utilize the techniques, skills, and modern tools necessary for the project.
3. Synthesize knowledge and use insight and creativity to better understand and improve design systems.

Module Content	(Project Duration: One Semester)

Students are expected to develop new skills and demonstrate the ability to develop prototypes to design prototype or working models related to an engineering product or a process.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews.

Recommended by Board of Studies	12-10-2022		
Approved by Academic Council	No. 68	Date	19-12-2022

Course Code	Course Title	L	T	P	C
BECE393J	Laboratory Project	0	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. The student will be able to conduct experiments on the concepts already learnt.
2. Analyse experimental data.
3. Present the results with appropriate interpretation.

Course Outcomes

1. Design and conduct experiments in order to gain hands-on experience on the concepts already studied.
2. Analyse and interpret experimental data.
3. Write clear and concise technical reports and research articles

Module Content	(Project Duration: One Semester)

Students are expected to perform experiments and gain hands-on experience on the theory courses they have already studied or registered in the ongoing semester. The theory course registered is not expected to have laboratory component and the student is expected to register with the same faculty who handled the theory course. This is mostly applicable to the elective courses. The nature of the laboratory experiments is depended on the course.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews.

Recommended by Board of Studies	12-10-2022		
Approved by Academic Council	No. 68	Date	19-12-2022

Course Code	Course Title	L	T	P	C
BECE394J	Product Development Project	0	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. Students will be able to translate a prototype to a useful product.
2. Apply relevant codes and standards during product development.
3. The student will be able to present his results by means of clear technical reports.

Course Outcomes

1. Demonstrate the ability to translate the developed prototype/working model to a viable product useful to society/industry.
2. Apply the appropriate codes/regulations/standards during product development.
3. Write clear and concise technical reports and research articles

Module Content	(Project Duration: Two Semesters)

Students are expected to translate the developed prototypes / working models into a product which has application to society or industry.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews

Recommended by Board of Studies	12-10-2022		
Approved by Academic Council	No. 68	Date	19-12-2022

Course Code	Course Title	L	T	P	C
BECE396J	Reading Course	0	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. The student will be able to analyse and interpret published literature for information pertaining to niche areas.
2. Scrutinize technical literature and arrive at conclusions.
3. Use insight and creativity for a better understanding of the domain of interest.

Course Outcomes

1. Retrieve, analyse, and interpret published literature/books providing information related to niche areas/focused domains.
2. Examine technical literature, resolve ambiguity, and develop conclusions.
3. Synthesize knowledge and use insight and creativity to better understand the domain of interest.

Module Content	(Project Duration: One Semester)
This is oriented towards reading published literature or books related to niche areas or focussed domains under the guidance of a faculty.	
Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews.	
Recommended by Board of Studies	12-10-2022
Approved by Academic Council	No. 68 Date 19-12-2022

Course Code	Course Title	L	T	P	C
BECE397J	Special Project	0	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. Students will be able to identify and solve problems in a time-bound manner.
2. Describe major approaches and findings in the area of interest.
3. Present the results in a clear and concise manner.

Course Outcomes

1. To identify, formulate, and solve problems using appropriate information and approaches in a time-bound manner.
2. To demonstrate an understanding of major approaches, concepts, and current research findings in the area of interest.
3. Write clear and concise research articles for publication in conference proceedings/peer-reviewed journals.

Module Content **(Project Duration: Three Semesters)**

This is an open-ended course in which the student is expected to work on a time bound research project under the supervision of a faculty. The result may be a tangible output in terms of publication of research articles in a conference proceeding or in a peer-reviewed Scopus indexed journal.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – project report to be submitted, presentation and project reviews.

Recommended by Board of Studies	12-10-2022		
Approved by Academic Council	No. 68	Date	19-12-2022

Course Code	Course Title	L	T	P	C
BECE398J	Simulation Project	0	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. Students will be able to simulate a real system.
2. Identify the variables which affect the system.
3. Describe the performance of a real system.

Course Outcomes

1. Demonstrate the ability to simulate and critically analyse the working of a real system.
2. Identify and study the different variables which affect the system elaborately.
3. Evaluate the impact and performance of the real system.

Module Content **(Project Duration: One Semester)**

The student is expected to simulate and critically analyse the working of a real system. Role of different variables which affect the system has to be studied extensively such that the impact of each step in the process is understood, thereby the performance of each step of the engineering process is evaluated.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – project report to be submitted, presentation and project reviews.

Recommended by Board of Studies	12-10-2022		
Approved by Academic Council	No. 68	Date	19-12-2022

Course Code	Course Title	L	T	P	C
BECE403E	Embedded Systems Design	3	0	2	4
Pre-requisite	BECE204L, BECE204P	Syllabus version			
		1.0			

Course Objectives

1. To acquaint students with definition, characteristics, challenges and design lifecycle of Embedded Systems by imparting the fundamental knowledge of I/O interfacing, serial communication protocols, wireless technologies, design using UML models
2. To familiarize the concepts and features of Real-time operating systems, task scheduling, and inter-task communication.
3. To impart various programming tools, modeling and simulation packages to program, design, simulate and build Embedded Systems

Course Outcomes

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

1. Design any application, based on the given specifications by keeping in mind different design metrics.
2. Apply the skills attained to differentiate Microprocessor/Microcontroller and interface various peripherals for a particular application.
3. Demonstrate proficiency in using device drivers, firmware and debugging tools.
4. Analyze the specific perspective of the embedded application using different modelling languages
5. Compare and contrast various wired and wireless protocols
6. Explore the concepts of RTOS and apply the knowledge for developing real-time systems

Module:1	**Embedded System Product Development**	**4 hours**

Characteristics of embedded systems, Classification of embedded systems, Embedded product development cycle, Embedded System Design Challenges, Performance and Benchmarking Tools.

Module:2	**Embedded Hardware Design**	**5 hours**

Processor classification - general purpose, customized, application specific processors, Microcontroller architectures (RISC, CISC), Embedded Memory, Strategic selection of processor and memory, Power Supply Design Considerations for Embedded Systems.

Module:3	**Embedded Software Development Environment**	**6 hours**

Cross assemblers/compilers, Linker, Runtime Library, Pre-processor Workflow, make files, Compiler Tool chains – gcc & ARM, Device Driver, Firmware, Middleware - Debugging tools: Emulators, Simulators, In-Circuit Debuggers, Logic Analyzer, Integrated Development Environment (IDE).

Module:4	**Modeling Embedded Systems**	**6 hours**

Control data flow graph, Finite state machine model, Petrinet Model, Unified model language

Module:5	**Programming the Peripherals of Microcontrollers**	**6 hours**

Programming GPIO pins, Timers / Counters, Watchdog Timer, PWM generation, ADC, DAC, LED, switches, keypad, LCD.

Module:6	**Emerging Communication Protocols**	**8 hours**

UART, SPI, I2C, NFC, CAN, Bluetooth, Zigbee, Wi-Fi				
Module:7	**Embedded Real –Time Operating Systems**			**8 hours**
Introduction to basic concepts of RTOS- Task, process & threads, Multiprocessing and Multitasking, Preemptive and non-preemptive scheduling, Schedulability Analysis, Inter process Communication, Performance Metrics of RTOS				
Module:8	**Contemporary Issues**			**2 hours**
	Total Lecture hours:			**45 hours**
Text Book(s)				
1.	Raj Kamal, “Embedded systems Architecture, Programming and Design”, 2017, Third Edition, McGraw Hill Education, India.			
Reference Books				
1.	Marilyn Wolf, “Computers as components: Principles of Embedded Computing System Design”, 2017, Fourth Edition, Morgan Kaufmann publications (Elsevier), United States.			
2.	Jiacun Wang, "Real-Time Embedded Systems", 2017, First Edition, Wiley Publishers, United States.			
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test				
Indicative Experiments				
1.	Experiments based on interfacing I/O devices			**4 hours**
2.	Experiments based on monitoring and control using sensors and actuators			**6 hours**
3.	Experiments based on wired Communications Protocols (UART, SPI, I2C, CAN)			**8 hours**
4.	Experiments based wireless Communications Protocols (Wi-Fi, Bluetooth)			**6 hours**
5.	Experiments based on RTOS			**6 hours**
	Total Laboratory Hours			**30 hours**
Mode of assessment: Continuous assessment and FAT				
Recommended by Board of Studies	28-02-2023			
Approved by Academic Council	No. 69	Date	16-03-2023	

Course Code	Course Title	L	T	P	C
BECE404L	Detection, Estimation and Modulation Theory	3	0	0	3
Pre-requisite	BECE207L	Syllabus version			
		1.0			

Course Objectives

1. To familiarize the students a hypothesis testing for various signal detection models.
2. To make them understand and apply Gaussian detection scheme.
3. To make them proficient in scalar and vector parameter estimation.
4. To let them develop an expertise in Kalman filter based estimation.

Course Outcomes

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

1. Postulate the hypothesis testing.
2. Apply Gaussian detection in suitable signal processing applications.
3. Develop a scheme to estimate scalar and vector parameters using the classical scheme of parameter estimation.
4. Estimate the parameters of importance through Gaussian estimation method.
5. Design and implement the estimators for continuous time random processes.
6. Apply Kalman filter based estimation in suitable signal processing applications.

Module:1	Classical Detection Theory	6 hours

Introduction - Simple Binary Hypothesis Tests - Decision Criteria - Performance: Receiver Operating Characteristic - M Hypotheses - Performance Bounds and Approximations - Monte Carlo Simulation - Importance Sampling -Simulation of PF - Simulation of PM - Independent Observations - Simulation of the ROC, Examples, Iterative Importance Sampling.

Module:2	Gaussian Detection	8 hours

Real and Circular Complex Gaussian Random Vectors - General Gaussian Detection - Equal Covariance Matrices - Independent Components with Equal and Unequal Variances - Eigen decomposition - Optimum Signal Design - Interference Matrix: Estimator – Subtractor - Low-Rank Models - Equal Mean Vectors - Diagonal Covariance Matrix on H0: Equal Variance – Independent and Identically Distributed Signal Components - Independent Signal Components: Unequal Variances - Correlated Signal Components - Low-Rank Signal Model - Symmetric Hypotheses - Uncorrelated Noise - Nondiagonal Covariance Matrix on H0, H1, Signal on Both Hypotheses, M Hypotheses

Module:3	Classical Parameter Estimation	6 hours

Introduction - Scalar Parameter Estimation - Random Parameters: Bayes Estimation - Nonrandom Parameter Estimation - Bayesian Bounds - Lower Bound on the MSE - Asymptotic Behavior - Exponential Family - Nonrandom Parameters - Random Parameters - Summary of Scalar Parameter Estimation

Module:4	Multiple Parameter Estimation	5 hours

Multiple Parameter Estimation - Estimation Procedures - Random Parameters - Nonrandom Parameters - Measures of Error- Nonrandom Parameters - Random Parameters - Bounds on Estimation Error - Nonrandom Parameters - Random Parameters - Hybrid Parameters - Hybrid Parameters - Joint ML and MAP Estimation

Module:5	Gaussian Estimation	7 hours

Introduction - Nonrandom Parameters - General Gaussian Estimation Model - Maximum Likelihood Estimation - Crammer–Rao Bound - Fisher Linear Gaussian Model - White Noise - Low-Rank Interference - Separable Models for Mean Parameters - Covariance Matrix Parameters - White Noise - Colored Noise - Rank One Signal Matrix Plus White Noise - Rank One Signal Matrix Plus Colored Noise - Linear Gaussian Mean and Covariance Matrix Parameters - White Noise -		
Module:6	**Estimation of Continuous-Time Random Processes**	**5 hours**
Optimum Linear Processors - Realizable Linear Filters: Stationary Processes, Infinite Past: Wiener Filters - Solution of Wiener–Hopf Equation - Errors in Optimum Systems - Unrealizable Filters - Closed-Form Error Expressions		
Module:7	**Kalman Filter Based Estimation**	**6 hours**
Gaussian - Markov Processes: Kalman Filter - Differential Equation Representation of Linear Systems and Random Process Generation - Kalman Filter - Realizable Whitening Filter - Generalizations - Implementation Issues - Bayesian Estimation of Non-Gaussian Models - The Extended Kalman Filter - Linear AWGN Process and Observations - Linear AWGN Process, Nonlinear AWGN Observations		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Harry L. Van Trees, “Detection Estimation and Modulation Theory”, John Wiley, 2013.
Reference Books	
1.	Bernard C. Levy, “Principles of Signal Detection and Parameter Estimation”, Springer New York, NY, ISBN 978-0-387-76542-6, 2008
2.	H. Vincent Poor, “An Introduction to Signal Detection and Estimation”, Springer New York, NY, 1994
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test	

Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE405L	Cognitive Radio Networks	3	0	0	3
Pre-requisite	BECE307L, BECE307P/ BECE317L, BECE317P	Syllabus version			
		1.0			

Course Objectives

1. To understand the principles and importance of cognitive radio in the context of next-generation networks
2. To analyze various spectrum sensing, access and management protocols
3. To introduce the challenges and opportunities associated with cognitive radio networks

Course Outcomes

At the end of the course, the student will have the ability to

1. Solve the fundamental challenges associated with security, medium access control and network layers.
2. Analyze the performance of various spectrum access, sensing and management schemes.
3. Create the network layer suitable for CRNs.
4. Use modern tools for the implementation of spectrum access, sensing and management protocols.
5. Make a presentation on assigned topic related to this course.

Module:1	Introduction to Cognitive Radio	6 hours

Evolution of Cognitive Radio, Cognitive Radio in 4G/5G Wireless Communications, Key Applications-Interoperability, Dynamic Spectrum Access, Regulatory Issues of Cognitive Access, Cognitive radio architecture, Introduction to software defined radio (SDR)-architecture and design principles, Reconfigurable wireless communication systems

Module:2	Spectrum Access and Sharing	6 hours

Unlicensed Spectrum Sharing, Licensed Spectrum Sharing, Secondary Spectrum Access, Non-Real-Time Spectrum Access and Sharing, Real-Time Spectrum Access and Sharing- Negotiated Access, Opportunistic Access, Overlay Approach, Underlay Approach

Module:3	Spectrum Sensing and Management	8 hours

Spectrum Sensing to Detect Specific Primary System-Conventional spectrum sensing, power control, Power-scaling power control, Cooperative spectrum sensing, Spectrum sensing procedure. Spectrum Sensing for Cognitive Multi-Radio Networks-Multiple system sensing, Radio resource sensing

Module:4	Medium Access Control	7 hours

MAC for cognitive radios, Multi-channel MAC-Collision avoidance/resolution, Access negotiation, Slotted-ALOHA with Rate-Distance Adaptability, CSMA with AMC-CSMA with spatial reuse transmissions, Cross layer power-rate control scheme

Module:5	Network Layer Design	6 hours

Routing in Mobile Ad Hoc Networks-Features of routing in cognitive radio networks (CRN), Dynamic source routing in MANET, Ad-hoc on-demand distance vector (AODV), Routing in CRN-Routing of dynamic and unidirectional cognitive radio links

in CRN, Control of CRN-Flow control and end-to-end error control, Network tomography, Self-Organized CRNs.		
Module:6	**Trusted Cognitive Radio Networks**	**6 hours**
Framework of Trust in CRN, Trusted Association and Routing, Trust with Learning-Modified Bayesian learning, Learning experiments for CRN, Security in CRN-Dilemma of CRN security, Requirements and challenges for preserving user privacy in CRNs, Implementation of CRN security.		
Module:7	**Spectrum Management**	**4 hours**
Spectrum Sharing, Spectrum Pricing, Mobility Management of Heterogeneous Wireless Networks, Regulatory Issues and International Standards		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours	**45 hours**

Text Book(s)	
1.	Ahmed Khattab, Dmitri Perkins, Magdy Bayoumi, Cognitive Radio Networks, Springer New York, NY, 2013.
Reference Books	
1.	Setoodeh, P., & Haykin, S. (2017). Fundamentals of cognitive radio. John Wiley & Sons.
2.	Alexander M. Wyglinski, Maziar Nekovee, Thomas Hou, Cognitive Radio Communications and Networks, Academic Press, Elsevier, 2010.
3.	Xiao, Y., & Hu, F. (Eds.). (2019). Cognitive radio networks. CRC press.
4.	Ezio Biglieri, Andrea J. Goldsmith, Larry J. Greenstein, Narayan B. Mandayam, H. Vincent Poor, “Principles of Cognitive Radio”, Cambridge, 2012

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test

Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE406E	FPGA Based System Design	2	0	2	3
Pre-requisite	BECE102L, BECE102P	Syllabus version			
		1.0			

Course Objectives

1. Understand FPGA Architecture and technologies
2. Modeling of complex digital sub-systems
3. Implementation of complex FPGA applications in real world scenario

Course Outcomes

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

1. Understand architectures of programmable logic devices
2. Understand various abstraction level in Verilog HDL
3. Construct high speed arithmetic and memory circuits
4. Analyze the synthesis and timing constraints/reports
5. Design the system using soft core processors
6. Develop the FPGA based system for various applications in signal processing
7. Develop and prototype digital systems using FPGA

Module:1	**Programmable Logic Devices**	**4 hours**

Types of Programmable Logic Devices: PLA, PAL, CPLD - FPGA Architecture – Programming Technologies-Chip I/O- Programmable Logic Blocks- Fabric and Architecture of FPGA.

Module:2	**HDL Fundamentals**	**3 hours**

Verilog Behavioral, Data Flow and Structural Modeling, Useful Modeling Techniques.

Module:3	**Implementation of Arithmetic system**	**5 hours**

Arithmetic Circuits: High Speed Adders, Carry look-ahead adder, Carry save adders, Conditional Sum adders, Sequential and Parallel Multipliers

Module:4	**FSM and memory modelling**	**5 hours**

Synchronous and Asynchronous FIFO – Single port and Dual port ROM and RAM - FSM Verilog modeling of Sequence detector - Serial adder - Vending machine.

Module:5	**Synthesis and Timing Analysis**	**3 hours**

Synthesis, Optimization of Speed: Introduction, Strategies for Timing Improvement; Optimization of Area, Optimization of power

Module:6	**SoC Design**	**4 hours**

Introduction to hardware – software codesign, Introduction to Qsys and Intel Quartus prime tool, Nios II Software Build Tools for Eclipse, Incorporate custom peripherals & instructions into an embedded system.

Module:7	**FPGA Applications**	**4 hours**

Embedded system design using FPGAs, DSP using FPGAs, Dynamic architecture using FPGAs, reconfigurable systems, application case studies. Simulation / implementation exercises of combinational, sequential and DSP kernels on Xilinx / Altera boards.

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	Michael D Ciletti, Advanced Digital Design with the Verilog HDL, Prentice Hall, Second Edition, 2017.			
Reference Books				
1.	Charles H Roth Jr, Lizy Kurian John and ByeongKil Lee Digital Systems Design using Verilog, Cengage Learning, First Edition, 2016.			
2.	Wayne Wolf, FPGA Based System Design, Prentices Hall Modern Semiconductor Design Series, 2011.			
3.	Ming-Bo Lin, Digital Systems Design and Practice: Using Verilog HDL and FPGAs, Create Space Independent Publishing Platform, Second Edition, 2015.			
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test				
Indicative Experiments				
1.	Design of adders and Multipliers			**6 hours**
2.	Design of FSM			**6 hours**
3.	Design of Memory circuits			**6 hours**
4.	Synthesis and Timing Analysis			**6 hours**
5.	System design using Qsys			**6 hours**
	Total Laboratory Hours			**30 hours**
Mode of assessment: Continuous assessment and FAT				
Recommended by Board of Studies	28-02-2023			
Approved by Academic Council	No. 69	Date	16-03-2023	

Course Code	Course Title	L	T	P	C
BECE407E	ASIC Design	2	0	2	3
Pre-requisite	BECE303L, BECE303P	Syllabus version			
	`	1.0			

Course Objectives

1. Explain the HDL coding guidelines, synthesizable HDL constructs and RTL synthesis Flow with respect to different cost functions.
2. Teach how to perform Static Timing Analysis for ASIC design.
3. Discuss the guidelines at each abstraction level in physical design
4. Provide detailed insight on importance of physical design verification

Course Outcomes

At the end of the course the student will be able to

1. Design a digital system by adhering to synthesizable HDL constructs.
2. Synthesize the given design by considering various constraints and to optimize the same.
3. Understand various timing parameters and perform Static Timing Analysis for ASIC design
4. Perform physical design by adhering to guidelines.
5. Apprehend the importance of physical design verification.
6. Design ASIC based systems using industry standard tools.

Module:1	**ASIC Design Methodology & Design Flow**	**3 hours**

Implementation Strategies for Digital ICs: Custom IC Design- Cell-based Design Methodology - Array based implementation approaches - Traditional and Physical Compiler based ASIC Flow.

Module:2	**Verilog HDL Coding Style for Synthesis**	**6 hours**

HDL Coding style – Guidelines and Recommendation - FSM Coding Guideline and Coding Style for Synthesis. Datapath and Control Logic Design.

Module:3	**RTL Synthesis**	**3 hours**

RTL synthesis Flow – Synthesis Design Environment & Constraints – Architecture of Logic Synthesizer - Technology Library Basics– Components of Technology Library –Synthesis Optimization- Technology independent and Technology dependent synthesis- Data path Synthesis – Low Power Synthesis - Formal Verification.

Module:4	**Basic Timing Analysis**	**4 hours**

Timing Parameter Definition – Setup Timing Check- Hold Timing Check- Multicycle Paths- Half-Cycle Paths- False Paths

Module:5	**Advanced Timing Analysis**	**5 hours**

Clock skew optimization – On-Chip Variations- AOCV-Time Borrowing- Setup and Hold Violation Fixing.

Module:6	**Physical Design**	**5 hours**

Detailed steps in Physical Design Flow- Guidelines for Floor plan, Placement, CTS and routing– ECO flow – Signal Integrity Issues.

Module:7	**Physical Design Verification**	**3 hours**

Timing Sign-off, Physical Verification – Signoff DRC and LVS, ERC, IR Drop Analysis, Electro-Migration Analysis and ESD Analysis.

Module:8	**Contemporary Issues**	**1 hours**

	Total Lecture hours:	**30 hours**
Text Book(s)		
1.	Vaibbhav Taraate, ASIC Design and Synthesis RTL Design Using Verilog, Springer, First Edition, 2021, Singapore.	
Reference Books		
1.	Khosrow Golshan, PHYSICAL DESIGN ESSENTIALS An ASIC Design Implementation Perspective, First Edition, 2010.	
2.	Michael John Sebastian Smith, Application-Specific Integrated Circuits, First Edition, 2002.	
3.	J. Bhasker and Rakesh Chadha, Static Timing Analysis for Nanometer Designs, Springer, First Edition, 2010, USA.	
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test		
Indicative Experiments		
1.	Design of Digital Architecture for given specification	**6 hours**
2.	Logical Synthesis of Digital Architecture	**6 hours**
3.	Netlist Optimization and Formal Verification	**6 hours**
4.	Physical Synthesis of Digital Architecture	**6 hours**
5.	Physical Verification of digital architecture	**6 hours**
	Total Laboratory Hours	**30 hours**
Mode of assessment: Continuous assessment and FAT		
Recommended by Board of Studies	28-02-2023	
Approved by Academic Council	No. 69	Date 16-03-2023

Course Code	Course Title	L	T	P	C
BECE408L	Microwave Integrated Circuits	3	0	0	3
Pre-requisite	BECE305L, BECE305P	Syllabus version			
		1.0			

Course Objectives

1. To have the essential knowledge of various planar microstrip circuits
2. To design and analyse various types of microwave planar circuits
3. To acquaint the fabrication techniques and tolerances for MIC circuits

Course Outcomes

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

1. Comprehend the importance of various microstrip lines and the losses due to various microstrip discontinuities
2. Design the lumped elements for microwave circuits
3. Analyze various microstrip resonators
4. Design and analyze band pass filters
5. Design the various microwave amplifiers, oscillators and mixers
6. Evaluate the performance of various fabrication techniques for planar circuits

Module:1	Planar transmission lines	6 hours

Introduction, types of MICs and their technology; Microstrip lines, strip lines, slotted lines, co-planar waveguides, coupled lines and SIW. Losses in microstrip transmission lines.

Module:2	Passive elements for MICs and discontinuities	8 hours

Lumped microstrip components: Design of microstrip and chip inductors, capacitors, resistors, Quasi lumped microstrip elements: Open and short circuited stubs (quarter wavelength, half wavelength). Interdigital capacitors, Approximate analysis. Discontinuities: Corners, symmetrical step, T-junction and series gaps

Module:3	Microstrip Resonators	6 hours

Analysis and Design of Quarter & Half wave length resonators, Ring resonators, Patch resonators and Slot resonators.

Module:4	Microwave Filter Design	7 hours

Introduction, Band pass filter: Insertion loss method, Conversion from low pass to band pass, Design of band pass filter using lumped elements, distributed elements, impedance inverters and coupled line filters.

Module:5	Microwave Amplifiers	6 hours

Single stage amplifier design for maximum and specific gain, Noise figure, Design of low noise amplifiers, Gain compression, Intermodulation distortion, third order intercept point, dynamic range.

Module:6	Microwave Oscillators and Mixers	5 hours

Conditions for oscillations, one port oscillator, two port oscillator (Transistor oscillators), Characteristics of mixer, Single ended diode mixer, Single ended FET mixer and Image reject mixer.

Module:7	MIC and MMIC Fabrication Technologies	5 hours

Hybrid MICs, Configuration, Dielectric substances, thick and thin film technology, LTCC, HTCC, Printed Circuit Board (PCB) Technology, Fabrication process of MMIC

Module:8	Contemporary Issues	2 hours

	Total Lecture hours:	**45 hours**
Text Book(s)		
1.	TC Edwards,MB Steer ,Foundations for Microstrip circuit design, 4e, 2016, John Wiley, UK	
Reference Books		
1.	Ali A Behagi, RF and Microwave Circuit Design: A Design Approach using ADS, 2017, 1e, Techno Search, India.	
2.	D. M. Pozar, Microwave engineering, 2020, 4e, John Wiley, India.	
3.	G Gonzalez, Microwave transistor amplifiers, 1997, 2e, PHI Inc., NJ	
Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test		
Recommended by Board of Studies	28-02-2023	
Approved by Academic Council	No. 69	Date 16-03-2023

Course Code	Course Title	L	T	P	C
BECE409E	Sensors Technology	2	0	2	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To attain a broad familiarity with the principle of sensing and different sensors for real world applications
2. Study the various sensor technologies for the measurement of physical quantities and develop suitable signal conditioning circuits.
3. Identify most suitable sensors for each measurement application and get acquainted with fabrication and interfacing process

Course Outcomes

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

1. Understand the sensors, sensor materials and sensor technologies.
2. Utilize various RLC and self-generating sensors for measuring physical quantities
3. Design appropriate signal conditioning and compensating circuits for RLC sensors
4. Fabricate various sensors using different fabrication techniques
5. Explore advanced sensing mechanisms.
6. Explore smart sensors and IOT for various sensor applications
7. Integrate the various sensors, work with them and interpret the data obtained from various applications.

Module:1	Sensing Mechanism	4 hours

Principles of Sensing: Resistive, Capacitive, Magnetic, Inductive, Piezoelectric, Piezo-resistance, Pyro-electric, Hall effect, RF sensing. Sensor materials and material properties. Sensor Technologies: Micro Technology, Micro-Electro-Mechanical Systems Technology, Nanotechnology. Example of Smart Sensors in Nature (Vision, Hearing, Touch, and Smell).

Module:2	RLC and Self Generating Sensors	4 hours

Resistive Sensors – Strain Gauges, Resistance Temperature Detectors, Thermistors, Light dependent resistors, Self and Mutual Inductive Transducers, LVDT, Capacitive Transducers, Variable Distance, Variable Area, Variable Dielectric Type Capacitive Sensors. Self-Generating Sensors – Thermoelectric Sensors, Piezoelectric Sensors, Pyroelectric sensors, Photovoltaic sensors, Electrochemical Sensors.

Module:3	Sensor Signal Conditioning	4 hours

DC Bridges for Resistance Measurements-Wheatstone Bridge, Kelvin Bridge. AC Bridges for Capacitance and Inductance Measurements-AC Bridge, Schering Bridge. Sensor Compensation Circuits-Temperature, Non-linearity and Offset Compensation.

Module:4	Sensor Fabrication	4 hours

Thick and Thin Film Sensor Fabrication – Screen Printing Technology, PVD, CVD, Fabrication of MEMS and NEMS Sensors – Lithography, Micromachining Techniques

Module:5	Advanced Sensors	4 hours

Position Encoders, Resonant Sensors, Sensors Based on Semiconductor Junctions, Fiber-Optic Sensors, Ultrasonic-Based Sensors, Biosensors, Superconducting Quantum Interference Devices (SQUIDs).		
Module:6	**Smart Sensors**	**4 hours**
Smart Transducers: Smart Sensors, Components of Smart Sensors, General Architecture of Smart Sensors, Evolution of Smart Sensors, Advantages, Application area of Smart Sensors.		
Module:7	**Sensors for IoT**	**4 hours**
Sensor-Cloud; Fog Computing, Smart Cities and Smart Homes, Connected Vehicles, Smart Grid, Industrial IoT, Case Study: Agriculture, Healthcare, Activity Monitoring		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Winncy Y. Du, "Resistive, Capacitive, Inductive, and Magnetic Sensor Technologies", 2019, 1st Edition, CRC press, London.
2.	B. C. Nakra and K. K. Chaudhary, "Instrumentation, Measurement and Analysis", 2016, 4th Edition, McGraw Hill Education India Private Limited.
Reference Books	
1.	A.K. Sawhney, "A Course in Electronic Measurements and Instrumentation", 2015, Dhanpat Rai & Co. (P) Limited.
2.	Ramón Pallás-Areny and John G. Webster, "Sensors and Signal Conditioning" 2012, 2nd Edition, John Wiley and Sons, Inc.
3.	Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press, 2017.
4.	Nihtianov, Stoyan, and Antonio Luque, eds. Smart sensors and MEMS: Intelligent sensing devices and microsystems for industrial applications. Woodhead Publishing, 2018.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test

List of Experiments		
1	Characteristics of Thermistor	**2 hours**
2	Characteristics of Strain Gauge	**2 hours**
3	Characteristics of Light Dependent Resistor	**2 hours**
4	Characteristics of Resistance Temperature Detector	**2 hours**
5	Characteristics of Angular potentiometer transducer model.	**2 hours**
6	Characteristics of LVDT	**2 hours**
7	Characteristics of Capacitive Level Sensor	**2 hours**
8	Characteristics of Thermocouples	**2 hours**
9	Characteristics of Photoelectric Tachometer	**2 hours**
10	Calibration of RTD and signal conditioning of RTD	**2 hours**
11	Calibration of Thermistor and signal conditioning of thermistor	**2 hours**
12	Characteristics of piezoelectric and Hall effect sensors	**2 hours**

13	Simulation of Biosensors/Chemical Sensors	**2 hours**
14	Simulation and design of sensors using MATLAB/LABVIEW/ COMSOL	**2 hours**
15	PC based Data acquisition system.	**2 hours**
	Total Laboratory Hours	**30 hours**
Mode of assessment: Continuous assessment &Final Assessment Test (FAT)		
Recommended by Board of Studies	28-02-2023	
Approved by Academic Council	No. 69	Date 16-03-2023

Course Code	Course Title	L	T	P	C
BECE410L	Micro-Electromechanical Systems	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

The course is aimed to

1. Introduce MEMS technology and their application as Sensors and actuators.
2. Comprehending various materials used in MEMS devices and also Micro-Nano fabrication techniques involved.

Course Outcomes

Students will be able to

1. Analyze the evolution of MEMS in various applications along with the scaling effects.
2. Understand the rudiments of materials like silicon, polymers, and metals used for realizing MEMS sensors.
3. Explore various fabrication techniques for MEMS devices
4. Analyze various sensing mechanisms and applications based on the same
5. Analyze various actuating mechanisms and applications based on the same
6. Acquaint the basics of Bio-MEMS and simple application models of BioMEMS
7. Understand flexible, printable types of devices and their applications

Module: 1	Micro-electro Mechanical Systems (MEMS)	5 hours

Historical background and evolution of Micro Electro Mechanical Systems (MEMS); Market for MEMS sensors **-**Real-world sensor/actuator examples; MEMS sensors in automobiles, smartphones, and Bio-medical applications.

Scaling in MEMS - Scaling of length, surface area, and volume — Scaling and surface tension **-**Scaling in optics - Scaling in the electrostatic and electromagnetic domain, Thermal domain - Scaling in microfluidics.

Module: 2	MEMS Materials and Properties	6 hours

Crystal, Substrates and wafers, Silicon and Silicon compounds - Silicon oxide and nitride; Single Crystal Silicon growth (CZ and FZ methods); Thin metal films (Cr, Au, Ti, Pt) **—** Polymers (SU8, PMMA, PDMS); Glass and Quartz; Paper; Nanoparticles – CNTs – Graphene - MoS_2; Choice and role of these substrates and materials in realizing miniature sensors.

Important material properties-Young modulus - Poisson's ratio - Density - Piezoresistive coefficients - Piezoelectric coefficients- TCR **-** Thermal conductivity **-** Material structure.

Module: 3	MEMS Fabrication Technology	7 hours

Silicon Wafer Cleaning - Oxidation - PVD (Thermal and E-beam evaporation, sputtering) - CVD - Lithography - Bulk- and surface-micromachining - LIGA - Bonding, and Packaging.

Surface Modification Techniques for Polymers, Soft-Lithography; Micro molding; Replica molding, and Micro contact printing.

Patterning Processes for flexible sensors - Printing technology, Non-Contact Type-Jet printing, Contact type - Screen printing, Gravure printing.

Module:4	Sensing Mechanisms and MEMS Sensors	7 hours

Sensing mechanisms – Capacitive, Piezoelectric, Piezoresistive, Electromagnetic, Optical, and Resonant sensing principles

MEMS Sensors: Pressure sensors, Accelerometers, Gas sensors, Flow sensors, Gyroscopes, Microcantilevers as sensors, Imaging and displays, and Fiber-optic communication devices.		
Module:5	**Actuation Mechanisms and MEMS Actuators**	**7 hours**
Actuation Mechanisms: Electrostatic, Piezoelectric, Electrothermal, Shape memory alloy (SMA) **MEMS actuators:** Microcantilever as actuators, Micro resonator, Microgripper, Micromirror, Micro motor, RF MEMS switch, Phase shifter, Varactor, and Micro heater.		
Module:6	**BioMEMS**	**6 hours**
Glucose sensors, In Vitro and In Vivo diagnostics, µ-TAS - Micromixer, Micro Valve, Micro Pump, Drug delivery systems, and MEMS. Application models – Implantable Biochips – Micro needles – Microelectrodes - Neural prosthesis and catheter end sensors, Paper-based microfluidic devices as biosensors.		
Module:7	**Flexible and Wearable Sensors**	**5 hours**
Textiles and polymers-based flexible sensors and applications – ECG, Blood Pressure, Epidermal Sensors, Tattoo based sensors, haptic gloves, strain sensors, pH sensors, and physiological sensors.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Tai-Ran Hsu, MEMS and Microsystems Design and Manufacture, 2017, 1st edition, Tata McGraw-Hill Publishing Company Ltd., India.
Reference Books	
1.	Run-Wei Li, Gang Liu , Flexible and Stretchable Electronics Materials, Designs, and Devices **–** 2019, Taylor and Francis, Singapore
2.	Marc J. Madou, Fundamentals of Microfabrication and Nanotechnology, 2018, CRC Press
3	Chang Liu , Foundations of MEMS, 2016, Pearson India

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz, and Final Assessment Test

Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE411L	Cryptography and Network Security	3	0	0	3
Pre-requisite	BECE401L, BECE401P/ BCSE308L, BCSE308P	Syllabus Version			
		1.0			

Course Objectives

1. To acquaint students with the basic concepts in need for security mechanism, classical and traditional Encryption techniques.
2. To impart knowledge to students regarding the significance of message confidentiality, Integrity and availability using Cryptography.
3. To acquaint the students to the different types of network & internet security and its significance.

Course Outcomes

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

1. Analyze OSI Security Architecture and Classical Encryptions.
2. Realize the various mathematical techniques in cryptography, including number theory, Finite Field, modulo operator, Elliptic Curve Arithmetic and Discrete Logarithm.
3. Analyze Modern block and stream ciphers, Data Encryption Standard (DES), Advanced Encryption Standard (AES), IDEA and Key Exchange Algorithms.
4. Analyze Asymmetric ciphers: RSA, ElGamal, RABIN Cryptosystem.
5. Comprehend the various types of data integrity and authentication schemes.
6. Infer the various network and Internet security mechanisms.

Module:1	**Cryptography: Overview**	**4 hours**
Introduction, OSI Security Architecture, Security Attacks, Security Services and Mechanisms, Classical Encryption Techniques.		
Module:2	**Mathematical Foundations**	**6 hours**
Number Theory and Finite Fields (Group, Ring and Fields), Fermat's and Euler's Theorems, The Chinese Remainder Theorem, Fast Exponentiation, Discrete Logarithms, Elliptic Curve Arithmetic, and Principles of Pseudorandom Number Generation.		
Module:3	**Symmetric Ciphers**	**8 hours**
Modern Block Ciphers and Modern Stream Ciphers- DES, IDEA, AES, Pseudorandom Number Generation based on symmetric cipher, Key Exchange Algorithm: Diffie-Hellman Key Exchange.		
Module:4	**Asymmetric Ciphers**	**7 hours**
RSA cryptosystem, ElGamal Cryptosystem, RABIN Cryptosystem, Elliptic Curve Cryptography simulating Elgamal, Pseudorandom Number Generation based on an asymmetric Cipher.		
Module:5	**Data Integrity Algorithms**	**7 hours**
Cryptographic Hash Functions: MD4, SHA-512, Whirlpool, Message Authentication Codes, Digital Signatures: RSA, Elgamal, Schnorr, DSS.		
Module:6	**Mutual Trust**	**5 hours**
Key Management and Distribution, X.509, User Authentication Protocols, Kerberos.		
Module:7	**Network and Internet Security**	**6 hours**
Transport Layer Security, Wireless LAN Security, Electronic mail Security, Firewalls, IoT Threats.		

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	William Stallings, "Cryptography and Network security: Principles and Practice", 8th Edition, 2020, Pearson Education, India.
Reference Books	
1.	Atul Kahate, “Cryptography And Network Security”, 4th Edition, 2019, The McGraw Hill Company.
2	Behrouz A.Forouzan, Debdeep Mukhopadhyay “Cryptography & Network Security”, 3rd edition, 2015, The McGraw Hill Company.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test

Recommended by Board of Studies	28-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course Code	Course Title	L	T	P	C
BECE399J	Summer Industrial Internship	0	0	0	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. The course is designed so as to expose the students to industry environment and to take up on-site assignment as trainees or interns.

Course Outcomes

1. Demonstrate professional and ethical responsibility.
2. Understand the impact of engineering solutions in a global, economic, environmental and societal context.
3. Develop the ability to engage in research and to involve in life-long learning.
4. Comprehend contemporary issues.

Module Content	4 Weeks (28 hours)
Four weeks of work at industry site. Supervised by an expert at the industry.	

Mode of Evaluation: Internship Report, Presentation and Project Review

Recommended by Board of Studies	12-10-2022		
Approved by Academic Council	No. 68	Date	19-12-2022

Course Code	Course Title	L	T	P	C
BECE497J	Project-I	0	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field.

Course Outcomes

1. Demonstrate professional and ethical responsibility.
2. Evaluate evidence to determine and implement best practice.
3. Mentor and support peers to achieve excellence in practice of the discipline.
4. Work in multi-disciplinary teams and provide solutions to problems that arise in multi-disciplinary work.

Module Content **(Project Duration: One Semester)**

Project may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.

Can be individual work or a group project, with a maximum of 3 students.

In case of group projects, the individual project report of each student should specify the individual's contribution to the group project.

Carried out inside or outside the university, in any relevant industry or research institution.

Publications in the peer reviewed journals / International Conferences will be an added advantage.

Mode of Evaluation: Assessment on the project - project report to be submitted, presentation and project reviews.

Recommended by Board of Studies	12-10-2022		
Approved by Academic Council	No. 68	Date	19-12-2022

Course Code	Course Title	L	T	P	C
BECE498J	Project-II / Internship	0	0	0	5
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field.

Course Outcomes

1. Formulate specific problem statements for ill-defined real life problems with reasonable assumptions and constraints.
2. Perform literature search and / or patent search in the area of interest.
3. Conduct experiments / Design and Analysis / solution iterations and document the results.
4. Perform error analysis / benchmarking / costing.
5. Synthesize the results and arrive at scientific conclusions / products / solution.
6. Document the results in the form of technical report / presentation.

Module Content **(Project Duration: One Semester)**

1. Project may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
2. Project can be for one or two semesters based on the completion of required number of credits as per the academic regulations.
3. Can be individual work or a group project, with a maximum of 3 students.
4. In case of group projects, the individual project report of each student should specify the individual's contribution to the group project.
5. Carried out inside or outside the university, in any relevant industry or research institution.
6. Publications in the peer reviewed Journals / International Conferences will be an added advantage.

Mode of Evaluation: Assessment on the project - project report to be submitted, presentation and project reviews.

Recommended by Board of Studies	12-10-2022		
Approved by Academic Council	No. 68	Date	19-12-2022