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

Specialization in Biomedical Engineering

(B.Tech ECE with Spec in Biomedical Engineering)

Curriculum

(*2022-23 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
Specialization with Biomedical 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 Specialization with Biomedical Engineering

PROGRAMME OUTCOMES (POs)

PO_01: Having an ability to apply mathematics and science in engineering applications.

PO_02: Having a clear understanding of the subject related concepts and of contemporary issues and apply them to identify, formulate and analyse complex engineering problems.

PO_03: Having an ability to design a component or a product applying all the relevant standards and with realistic constraints, including public health, safety, culture, society and environment

PO_04: Having an ability to design and conduct experiments, as well as to analyse and interpret data, and synthesis of information

PO_05: Having an ability to use techniques, skills, resources and modern engineering and IT tools necessary for engineering practice

PO_06: Having problem solving ability- to assess social issues (societal, health, safety, legal and cultural) and engineering problems

PO_07: Having adaptive thinking and adaptability in relation to environmental context and sustainable development

PO_08: Having a clear understanding of professional and ethical responsibility

PO_09: Having cross cultural competency exhibited by working as a member or in teams

PO_10: Having a good working knowledge of communicating in English – communication with engineering community and society

PO_11: Having a good cognitive load management skills related to project management and finance

PO_12: Having interest and recognise the need for independent and lifelong learning

B. Tech Electronics and Communication Engineering Specialization with Biomedical Engineering

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On the completion of B.Tech ECE Specialization in Biomedical Engineering degree, Students will be able to

PSO1. Design and develop variety of biomedical components and systems.

PSO2. Apply modern engineering tools to solve complex Electronics & Communication Engineering and biomedical problems.

PSO3: Use modern tools and techniques to solve contemporary problems in the field of biomedical engineering.

CREDIT INFO		
S.no	**Catagory**	**Credits**
1	Foundation Core	51
2	Discipline-linked Engineering Sciences	10
3	Discipline Core	51
4	Specialization Elective	23
5	Projects and Internship	9
6	Open Elective	15
7	Bridge Course	0
8	Non-graded Core Requirement	11
Total Credits		170

Foundation Core									
sl.no	**Course Code**	**Course Title**	**Course Type**	**Version**	**L**	**T**	**P**	**J**	**Credits**
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	Credits
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	Credits
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

Specialization Elective									
sl.no	Course Code	Course Title	Course Type	Version	L	T	P	J	Credits
1	BBMD101L	Anatomy and Physiology	Theory Only	1.0	2	0	0	0	2.0
2	BBMD101P	Anatomy and Physiology Lab	Lab Only	1.0	0	0	2	0	1.0

Specialization Elective									
3	BBMD102L	Biomedical Instrumentation and Measurements - I	Theory Only	1.0	2	0	0	0	2.0
4	BBMD102P	Biomedical Instrumentation and Measurements - I Lab	Lab Only	1.0	0	0	2	0	1.0
5	BBMD201L	Biomedical Instrumentation and Measurements - II	Theory Only	1.0	3	0	0	0	3.0
6	BBMD202L	Bio Signal Analysis	Theory Only	1.0	2	0	0	0	2.0
7	BBMD202P	Bio Signal Analysis Lab	Lab Only	1.0	0	0	2	0	1.0
8	BBMD203L	Medical Image Analysis	Theory Only	1.0	2	0	0	0	2.0
9	BBMD203P	Medical Image Analysis Lab	Lab Only	1.0	0	0	2	0	1.0
10	BBMD204L	Medical Imaging Techniques	Theory Only	1.0	3	0	0	0	3.0
11	BBMD205L	Biomaterials	Theory Only	1.0	3	0	0	0	3.0
12	BBMD206L	Biomechanics	Theory Only	1.0	3	0	0	0	3.0
13	BBMD207L	Hospital Management	Theory Only	1.0	3	0	0	0	3.0
14	BBMD208L	Telemedicine and Telecare	Theory Only	1.0	3	0	0	0	3.0
15	BBMD209L	Health Informatics	Theory Only	1.0	3	0	0	0	3.0
16	BBMD210L	Medical Robotics	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	Credits
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	Credits
1	BECE320E	Embedded C Programming	Embedded Theory and Lab	1.0	2	0	2	0	3.0
2	BECE351E	Internet of Things	Embedded Theory and Lab	1.0	1	0	2	0	2.0
3	BECE352E	IoT Domain Analyst	Embedded Theory and Lab	1.0	1	0	2	0	2.0
4	BECE391J	Technical Answers to Real Problems Project	Project	1.0	0	0	0	0	3.0
5	BECE392J	Design Project	Project	1.0	0	0	0	0	3.0
6	BECE393J	Laboratory Project	Project	1.0	0	0	0	0	3.0
7	BECE394J	Product Development Project	Project	1.0	0	0	0	0	3.0
8	BECE396J	Reading Course	Project	1.0	0	0	0	0	3.0
9	BECE397J	Special Project	Project	1.0	0	0	0	0	3.0
10	BECE398J	Simulation Project	Project	1.0	0	0	0	0	3.0
11	BHUM201L	Mass Communication	Theory Only	1.0	3	0	0	0	3.0
12	BHUM202L	Rural Development	Theory Only	1.0	3	0	0	0	3.0

Open Elective									
13	BHUM203L	Introduction to Psychology	Theory Only	1.0	3	0	0	0	3.0
14	BHUM204L	Industrial Psychology	Theory Only	1.0	3	0	0	0	3.0
15	BHUM205L	Development Economics	Theory Only	1.0	3	0	0	0	3.0
16	BHUM206L	International Economics	Theory Only	1.0	3	0	0	0	3.0
17	BHUM207L	Engineering Economics	Theory Only	1.0	3	0	0	0	3.0
18	BHUM208L	Economics of Strategy	Theory Only	1.0	3	0	0	0	3.0
19	BHUM209L	Game Theory	Theory Only	1.0	3	0	0	0	3.0
20	BHUM210E	Econometrics	Embedded Theory and Lab	1.0	2	0	2	0	3.0
21	BHUM211L	Behavioral Economics	Theory Only	1.0	3	0	0	0	3.0
22	BHUM212L	Mathematics for Economic Analysis	Theory Only	1.0	3	0	0	0	3.0
23	BHUM213L	Corporate Social Responsibility	Theory Only	1.0	3	0	0	0	3.0
24	BHUM214L	Political Science	Theory Only	1.0	3	0	0	0	3.0
25	BHUM215L	International Relations	Theory Only	1.0	3	0	0	0	3.0
26	BHUM216L	Indian Culture and Heritage	Theory Only	1.0	3	0	0	0	3.0
27	BHUM217L	Contemporary India	Theory Only	1.0	3	0	0	0	3.0
28	BHUM218L	Financial Management	Theory Only	1.0	3	0	0	0	3.0
29	BHUM219L	Principles of Accounting	Theory Only	1.0	3	0	0	0	3.0
30	BHUM220L	Financial Markets and Institutions	Theory Only	1.0	3	0	0	0	3.0
31	BHUM221L	Economics of Money, Banking and Financial Markets	Theory Only	1.0	3	0	0	0	3.0
32	BHUM222L	Security Analysis and Portfolio Management	Theory Only	1.0	3	0	0	0	3.0
33	BHUM223L	Options , Futures and other Derivatives	Theory Only	1.0	3	0	0	0	3.0
34	BHUM224L	Fixed Income Securities	Theory Only	1.0	3	0	0	0	3.0
35	BHUM225L	Personal Finance	Theory Only	1.0	3	0	0	0	3.0
36	BHUM226L	Corporate Finance	Theory Only	1.0	3	0	0	0	3.0
37	BHUM227L	Financial Statement Analysis	Theory Only	1.0	3	0	0	0	3.0
38	BHUM228L	Cost and Management Accounting	Theory Only	1.0	3	0	0	0	3.0
39	BHUM229L	Mind, Embodiment and Technology	Theory Only	1.0	3	0	0	0	3.0
40	BHUM230L	Health Humanities in Biotechnological Era	Theory Only	1.0	3	0	0	0	3.0
41	BMEE102P	Engineering Design Visualisation Lab	Lab Only	1.0	0	0	4	0	2.0
42	BMEE201L	Engineering Mechanics	Theory Only	1.0	2	1	0	0	3.0
43	BSTS301P	Advanced Competitive Coding - I	Soft Skill	1.0	0	0	3	0	1.5
44	BSTS302P	Advanced Competitive Coding - II	Soft Skill	1.0	0	0	3	0	1.5
45	CFOC102M	Introduction to Cognitive Psychology	Online Course	1.0	0	0	0	0	3.0
46	CFOC103M	Introduction to Political Theory	Online Course	1.0	0	0	0	0	3.0
47	CFOC104M	Six Sigma	Online Course	1.0	0	0	0	0	3.0
48	CFOC113M	Contemporary Themes in India's Economic Development and Economic Survey	Online Course	1.0	0	0	0	0	3.0
49	CFOC115M	Design and Analysis of Algorithms	Online Course	1.0	0	0	0	0	2.0
50	CFOC119M	Training of Trainers	Online Course	1.0	0	0	0	0	3.0
51	CFOC120M	Knowledge Management	Online Course	1.0	0	0	0	0	2.0
52	CFOC122M	Educational Leadership	Online Course	1.0	0	0	0	0	2.0
53	CFOC126M	Data Analysis and Decision Making - III	Online Course	1.0	0	0	0	0	3.0

Open Elective									
54	CFOC128M	Business Analytics and Text Mining Modeling Using Python	Online Course	1.0	0	0	0	0	2.0
55	CFOC130M	Human Resource Development	Online Course	1.0	0	0	0	0	3.0
56	CFOC133M	E-Business	Online Course	1.0	0	0	0	0	3.0
57	CFOC134M	Innovation, Business Models and Entrepreneurship	Online Course	1.0	0	0	0	0	2.0
58	CFOC136M	Toyota Production System	Online Course	1.0	0	0	0	0	2.0
59	CFOC145M	Fabrication Techniques for MEMs - based sensors: clinical Perspective	Online Course	1.0	0	0	0	0	3.0
60	CFOC148M	Introduction to Wireless and Cellular Communications	Online Course	1.0	0	0	0	0	3.0
61	CFOC158M	Reinforcement Learning	Online Course	1.0	0	0	0	0	3.0
62	CFOC159M	Applied Natural Language Processing	Online Course	1.0	0	0	0	0	3.0
63	CFOC160M	Python for Data Science	Online Course	1.0	0	0	0	0	1.0
64	CFOC161M	Data Science for Engineers	Online Course	1.0	0	0	0	0	2.0
65	CFOC165M	Software testing	Online Course	1.0	0	0	0	0	3.0
66	CFOC166M	Hardware Modeling using Verilog	Online Course	1.0	0	0	0	0	2.0
67	CFOC171M	Introduction to Haskell Programming	Online Course	2.0	0	0	0	0	3.0
68	CFOC177M	Drug Delivery: Principles and Engineering	Online Course	1.0	0	0	0	0	3.0
69	CFOC178M	Functional Genomics	Online Course	1.0	0	0	0	0	1.0
70	CFOC179M	Introduction to Proteogenomics	Online Course	1.0	0	0	0	0	3.0
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	CFOC223M	Privacy and Security in Online Social Media	Online Course	1.0	0	0	0	0	2.0
78	CFOC227M	GPU Architectures and Programming	Online Course	1.0	0	0	0	0	3.0
79	CFOC228M	Multi-Core Computer Architecture - Storage and Interconnects	Online Course	1.0	0	0	0	0	2.0
80	CFOC229M	Data Analytics with Python	Online Course	1.0	0	0	0	0	3.0
81	CFOC231M	Google Cloud Computing Foundation Course	Online Course	1.0	0	0	0	0	2.0
82	CFOC233M	Enhancing Soft Skills and Personality	Online Course	1.0	0	0	0	0	2.0
83	CFOC234M	Introduction to Airplane Performance	Online Course	1.0	0	0	0	0	2.0
84	CFOC235M	Rocket Propulsion	Online Course	1.0	0	0	0	0	3.0
85	CFOC237M	Sustainable Architecture	Online Course	1.0	0	0	0	0	3.0
86	CFOC265M	Geomorphology	Online Course	1.0	0	0	0	0	3.0
87	CFOC277M	Process Control - Design, Analysis and Assessment	Online Course	1.0	0	0	0	0	3.0
88	CFOC287M	Introduction to Blockchain Technology and Applications	Online Course	1.0	0	0	0	0	2.0
89	CFOC288M	Foundations of Cryptography	Online Course	1.0	0	0	0	0	3.0
90	CFOC292M	Programming in Java	Online Course	1.0	0	0	0	0	3.0
91	CFOC293M	Data Base Management System	Online Course	1.0	0	0	0	0	2.0
92	CFOC294M	Introduction to Algorithms and Analysis	Online Course	1.0	0	0	0	0	3.0

Open Elective									
93	CFOC304M	Programming, Data Structures And Algorithms Using Python	Online Course	1.0	0	0	0	0	2.0
94	CFOC306M	Social Networks	Online Course	1.0	0	0	0	0	3.0
95	CFOC311M	User-centric Computing for Human-Computer Interaction	Online Course	1.0	0	0	0	0	3.0
96	CFOC312M	Cloud Computing and Distributed Systems	Online Course	1.0	0	0	0	0	2.0
97	CFOC329M	Design, Technology and Innovation	Online Course	1.0	0	0	0	0	2.0
98	CFOC334M	High Power Multilevel Converters-Analysis, Design and Operational Issues	Online Course	1.0	0	0	0	0	3.0
99	CFOC367M	Electrical Machines - II	Online Course	1.0	0	0	0	0	3.0
100	CFOC388M	Energy Resources, Economics and Environment	Online Course	1.0	0	0	0	0	3.0
101	CFOC389M	Literary Criticism (From Plato to Leavis)	Online Course	1.0	0	0	0	0	3.0
102	CFOC393M	Introduction to Cultural Studies	Online Course	1.0	0	0	0	0	3.0
103	CFOC394M	Introduction to Basic Spoken Sanskrit	Online Course	1.0	0	0	0	0	1.0
104	CFOC395M	Speaking Effectively	Online Course	1.0	0	0	0	0	2.0
105	CFOC398M	English Language for Competitive Exams	Online Course	1.0	0	0	0	0	3.0
106	CFOC399M	English Literature for competitive Exams	Online Course	1.0	0	0	0	0	2.0
107	CFOC403M	Patent Drafting for Beginners	Online Course	1.0	0	0	0	0	1.0
108	CFOC404M	Patent Law for Engineers and Scientists	Online Course	1.0	0	0	0	0	3.0
109	CFOC406M	Human Behaviour	Online Course	1.0	0	0	0	0	2.0
110	CFOC407M	Introduction to Modern Indian Political Thought	Online Course	1.0	0	0	0	0	3.0
111	CFOC409M	Literature, Culture and Media	Online Course	1.0	0	0	0	0	3.0
112	CFOC410M	Introduction to Brain & Behaviour	Online Course	1.0	0	0	0	0	2.0
113	CFOC449M	Product Design and Manufacturing	Online Course	1.0	0	0	0	0	3.0
114	CFOC475M	IC Engines and Gas Turbines	Online Course	1.0	0	0	0	0	3.0
115	CFOC484M	Production and Operation Management	Online Course	1.0	0	0	0	0	3.0
116	CFOC485M	Services Marketing: Integrating People, Technology, Strategy	Online Course	1.0	0	0	0	0	2.0
117	CFOC487M	Financial Institutions and Markets	Online Course	1.0	0	0	0	0	3.0
118	CFOC488M	Business Analytics For Management Decision	Online Course	1.0	0	0	0	0	3.0
119	CFOC498M	Business Statistics	Online Course	1.0	0	0	0	0	3.0
120	CFOC503M	Marketing Analytics	Online Course	1.0	0	0	0	0	3.0
121	CFOC508M	Entrepreneurship	Online Course	1.0	0	0	0	0	3.0
122	CFOC526M	Quantum Mechanics I	Online Course	1.0	0	0	0	0	3.0
123	CFOC543M	International Business	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**	**Credits**
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
3	BMAT100N	Mathematics	Theory Only	1.0	3	1	0	0	4.0

Non-graded Core Requirement									
sl.no	**Course Code**	**Course Title**	**Course Type**	**Version**	**L**	**T**	**P**	**J**	**Credits**
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

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 $\lambda/8$, $\lambda/4$ and $\lambda/2$.

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

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

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	ILITIPIC 2 11
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 – AbstracUSummary- 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		
Aooroved 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, FA I

Recommended by Board of Studies	24-06-2021		
Approved by Academic Counc	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 Counc	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 CO2 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 Skil**	**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 detai**	**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

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
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

Course code	Course Title	L	T	P	C
BBMD101L	Anatomy and Physiology	2	0	0	2
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To discuss insight into the human body structure and function.
2. To discover the physiology of different organs and systems of the human body.
3. To identify the various nutritional aspects and biomolecules of human body.

Course Outcome

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

1. Conceive the engineering knowledge and basic concepts of biology including cell and its biomolecules.
2. Interpret and analyze the problem statements involved in chemical coordination using various systems of the human body.
3. Analyze and apply the principles and commit to professional ethics and the concept of biological practice in healthcare.
4. Interpret and evaluate the mechanism of body fluids and human skeleton.
5. Identify the importance of biology and ability to engage in life-long learning for technological change.

Module:1	Cells, tissues, organization of the body and its nutrition	4hours

The Cell structure and functions – Transport across the cell membrane – Tissues – Tissue regeneration – Organisation of the body – Anatomical terms – Cavities if the body – Disorders of cells and tissues – Carbohydrates – Proteins – Fats – Vitamins – Mineral salts.

Module:2	Communication through blood and Cardiovascular system	4 hours

Composition of blood – Cellular content of blood – Erythrocytes – Development and life span of RBC's – Leukocytes – Thrombocytes – Erythrocyte disorders – Leukocyte disorders – Hemorrhagic diseases - Blood vessels – Heart – Circulation of the blood - Diseases of the heart – Disorders of blood pressure.

Module:3	The nervous system	4 hours

Neurones – Central nervous system – Brain – Spinal cord – Peripheral nervous system – Autonomic nervous system – Functions – Response of nervous tissue to injury – Disorders of the brain – Diseases of the spinal cord – Tumors of the nervous system.

Module:4	The Special senses	4 hours

Hearing and the ear – Physiology of hearing – Balance and the ear – Sight and the eye – Structure and physiology of sight – Sense of smell - Physiology of smell – Sense of taste – Physiology of taste – Disease of the ear – Diseases of the eye – Refractive errors of the eye.

Module:5	The endocrine system	4 hours

Pituitary gland and hypothalamus – Disorders – Thyroid gland – Disorders – Parathyroid gland Disorders -– Adrenal gland – Pancreatic islets - Disorders– Pineal gland – Thymus gland – Local hormones.

Module:6	The respiratory system	4 hours

Nose and nasal cavity – Pharynx – Larynx – Trachea – Broncho and smaller air passages – Bronchioles - alveoli – Lungs – Respiration – Disorders of upper respiratory tract – Diseases of bronchi – Disorders of the lungs.

Module:7	The digestive system and The Skeletal system	4hours

Organs of the digestive system – Structure of alimentary canal – Mouth – Salivary glands – Oesophagus – Stomach – Large intestine – Pancreas – Liver – Biliary tract – Metabolism –

Diseases associated with digestive system. Bones – Types of bones – Bone structure – Development of bone tissues – Functions of bones – Axial skeleton – Skull – Cranium – Thoracic cage – Appendicular skeleton – Healing of bones – Diseases of bones – Infection – Developmental abnormalities of bone.			
Module:8	**Contemporary Issues**		**2 hours**
	Total Lecture hours:		**30 hours**
Text Book(s)			
1.	Ross and Wilson, Anatomy and Physiology in Health and Illness, 13Ed (Ie), 2018.		
Reference Books			
1.	Guyton and Hall, Textbook of Medical Physiology, Elsevier India, 2nd Edition (South Asia), 2019		
2.	Tortora G.J, Anatomy & Physiology with Workbook, 2017		
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
BBMD101P	Anatomy and Physiology Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To discuss the insights of skeletal system and bones of the human body.
2. To discover the different parts of human organs.
3. To identify the different types of blood groups and blood matching.

Course Outcome

The student will be able to

1. Conceive the engineering knowledge and basic concepts of human bones and skeletal system.
2. Identify the different parts of various organs of the human body.
3. Demonstrate the different parts of the brain and its models.
4. Identify the importance of different types of blood group and its evaluation.
5. Interpret and analyze the mechanism of pulse and blood pressure.

Indicative Experiments

1.	Demonstration of skeletal system and identification of bones of human skeleton	**6 hours**
2.	Demonstration of parts of the brain on the models	**6 hours**
3.	Demonstration of thoracic, abdominal and pelvic organs	**6 hours**
4.	Evaluation of blood groups	**6 hours**
5.	Analysis of pulse and blood pressure	**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
BBMD102L	Biomedical Instrumentation and Measurements - I	2	0	0	2
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To elaborate the development of biomedical instrumentation and its application in medical field, and the concepts behind measuring the blood pressure, cardiac output and heart sounds.
2. To revise the basics of EEG and to introduce the concepts of measuring the brain activity, and to familiarize them with the basic principle, working and design of various automated diagnostic equipment related to ENT and ophthalmology.
3. To elaborate the need of minimally invasive techniques in medical field and to develop the understandingtowards the medical laboratory equipment.
4. To deliver the awareness towards shocks and hazards.

Course Outcome

1. To furnish information on the development of biomedical instrumentation and its application in medical field.
2. To calibrate and trouble-shoot the basic instruments and to measure various parameters related to medical application.
3. To critically analyze the basics of non-invasive diagnostic techniques and to implement user-defined designs for diagnostic equipment.
4. To develop instrumentation systems for various automated biomedical equipment
5. To design an instrument for medical applications for the changing demand.

Module:1	Medical Instrumentation	5 hours

Physiological System of Human Body, Sources of Biomedical Signals, Basic Medical Instrumentation System, Performance Requirements of Medical Instrumentation Systems, Intelligent Medical Instrumentation Systems, General Constraints in Design of Medical Instrumentation Systems, Regulation of Medical Devices.

Module:2	Recording Systems and Biomedical Recorders	5 hours

Basic Recording System, General Considerations for Signal Conditioners, Preamplifiers, Main Amplifier and Driver Stage, Writing Systems, Electrocardiograph (ECG), Phonocardiograph (PCG), Electroencephalograph (EEG), Electromyograph (EMG), Biofeedback Instrumentation.

Module:3	Patient Monitoring Systems	4 hours

Cardiac Monitor, Bedside Patient Monitoring Systems, Central Monitors, Measurement of Heart Rate and Pulse Rate, Blood Pressure Measurement, Measurement of Respiration Rate.

Module:4	Oximeters, Blood Flowmeters and Pulmonary Function Analysers	4 hours

Oximetry: Ear Oximeter, Pulse Oximeter, Blood Flowmeters: Ultrasonic Blood Flowmeters, NMR Blood Flowmeter, Laser Doppler Blood Flowmeter. Pulmonary Function Analysers: Pulmonary Function Measurements, Spirometry, Pneumotachometers, Pulmonary Function Analyzers, Respiratory Gas Analyzers.

Module:5	Clinical Laboratory Instruments	4 hours

Colorimeters, Spectrophotometers, Automated Biochemical Analysis Systems, Clinical Flame Photometers, Complete Blood Gas Analyzer, Coulter Counters.

Module:6	Audiometers and Hearing Aids	3 hours

Basic Audiometer, Pure Tone Audiometer, Speech Audiometer, Evoked Response Audiometry System, Calibration of Audiometers, Hearing Aids.

Module:7	Patient Safety	3 hours

Electric Shock Hazards, Leakage Currents, Safety Codes for Electromedical Equipment, Electrical Safety Analyzer, Testing of Biomedical Equipment.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**30 hours**
Text Book(s)		
1.	R.S. Khandpur Hand Book of Biomedical Instrumentation, 3rd edition, – Tata McGraw Hill publication, New Delhi, 2014.	
Reference Books		
1.	Joseph Carr, Brown, Introduction to Biomedical Equipment, 4th edition, Pearson, 2015.	
2.	Leslie Cromwell, “Biomedical Instrumentation and measurement”, 2nd edition, PHI, New Delhi, 2015.	
3.	John G. Webster, “Medical Instrumentation Application and Design”, 5th edition, John Wiley and sons, New York, 2015.	
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
BBMD102P	Biomedical Instrumentation and Measurements - I Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To revise the basics of medical instrumentation and to familiarize them with the basic principle, working and design of various automated diagnostic equipment.
2. To elaborate the need of minimally invasive techniques in medical field and to develop the understandingtowards the medical laboratory equipment.
3. To deliver the awareness towards shocks and hazards.

Course Outcome

1. To calibrate and trouble-shoot the basic instruments and to measure various parameters related to medical application.
2. To develop instrumentation systems for various automated biomedical equipment.
3. To design an instrument for medical applications for the changing demand.

Indicative Experiments

1.	Measurement of Blood Pressure using sphygmomanometer	**2 hours**
2.	Analyze Instrumentation amplifier for biomedical signals	**2 hours**
3.	Design pulse oximeter and segregate the second derivative to detect Heart ailments.	**2 hours**
4.	Design an ECG set-up to record three lead ECG and measure the R-R interval, Heart Rate and the cardio vector.	**4 hours**
5.	Simulate the real time EEG monitoring and measure the amplitude and frequency of Alpha, Beta, Gamma and Delta waves.	**3 hours**
6.	Hands on training and calibration of Auto analyzer and coulter counter.	**2 hours**
7.	Design and develop a hearing aid to improve the hearing capability.	**3 hours**
8.	Observe the real time patient monitoring system (Visit to Hospital)	**6 hours**
9.	Observe the patient safety systems followed in hospital set-up (Visit to Hospital).	**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
BBMD201L	Biomedical Instrumentation and Measurements - II	3	0	0	3
Pre-requisite	BBMD102L, BBMD102P	Syllabus version			
		1.0			

Course Objectives

1. To discuss the various functional blocks in diagnostic and therapeutic equipment.
2. To impart knowledge about the biomedical equipment so that the student can design, calibrate, and operate with care and safety.

Course Outcome

1. To assess the functioning of cardiac pacemakers and defibrillators to distinguish the different levels of equipment used in operation theatres.
2. To conceptualize and design user specific first end medical equipment.
3. To inspect and interpret the functioning of therapeutic and surgical equipment
4. To propose designs for radiotherapy equipment and analyze the functioning of Drug delivery systems.
5. To communicate effectively to impart physical science concepts and understand how they can be used in medical diagnostics and therapeutics.

Module:1	**Cardiac Pacemakers and Defibrillators**	**6 hours**

Need for Cardiac Pacemaker, External Pacemakers, Implantable Pacemakers, Pacing System Analyser, Need for a Defibrillator, DC Defibrillator, Implantable Defibrillators, Pacer—cardioverter—defibrillator, Defibrillator Analysers.

Module:2	**Laser and Surgical Instruments**	**6 hours**

Principle of Surgical Diathermy, Diathermy Machine, Surgical Diathermy Analysers, Laser Applications in Biomedical Field**:** The Laser, Pulsed Ruby Laser, Nd-YAG Laser, Helium-Neon Laser, Argon Laser, CO2 Laser, Excimer Lasers, Semiconductor Lasers, Laser Safety.

Module:3	**Physiotherapy and Electrotherapy Equipment**	**6 hours**

Short-wave Diathermy, Microwave Diathermy, Ultrasonic Therapy Unit, Pain Relief Through Electrical Stimulation, Bladder Stimulators, Cerebellar Stimulators.

Module:4	**Haemodialysis Machines and Lithotriptors**	**6 hours**

Artificial, Dialyzers, Membranes for Haemodialysis, Haemodialysis Machine, Portable Kidney Machines. Lithotriptors, Extra-corporeal Shock-wave Therapy.

Module:5	**Anaesthesia Machine and Ventilators**	**6 hours**

Need for Anaesthesia, Anaesthesia Machine, Electronics in the Anaesthetic Machine, Ventilators, Types of Ventilators, Modern Ventilators, High Frequency Ventilators, Humidifiers, Nebulizers and Aspirators.

Module:6	**Radiotherapy Equipment**	**6 hours**

Use of High Voltage X-ray Machines, Development of Betatron, Cobalt-60 Machine, Medical Linear Accelerator Machine.

Module:7	**Automated Drug Delivery Systems**	**7 hours**

Infusion Pumps, Components of Drugs Infusion Systems, Implantable Infusion Systems, Closed-loop Control in Infusion Systems, Examples of Typical Infusion Pumps.

Module:8	**Contemporary Issues**	**6 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1. R.S. Khandpur Hand Book of Biomedical Instrumentation, 3rd edition, – Tata McGraw Hill publication, New Delhi, 2014.

Reference Books

1. John G. Webster, “Medical Instrumentation Application and Design”, 5th edition, John

	Wiley and sons, NewYork, 2020.			
2.	Leslie Cromwell, “Biomedical Instrumentation and measurement”, 2nd edition, PHI, New Delhi, 2015.			
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
BBMD202L	Bio Signal Analysis	2	0	0	2
Pre-requisite	BECE202L	Syllabus version			
		1.0			

Course Objectives

1. To understand the fundamentals of biomedical signal acquisition and signal classification.
2. To impart knowledge about physiological signal processing and analysis.
3. To apply adaptive filtering techniques for cancelling noise and interference in the various bio-signals.

Course Outcome

1. Examine the basic signal processing for bio-signals.
2. Illustrate the knowledge about spectral analysis.
3. Investigate the cardiological signal processing methods.
4. Formulate and study an algorithm for bio-signal processing in frequency domain.
5. Describe an adaptive filtering algorithms for biosignals.

Module:1	**Physiological Signals**	**3 hours**

Nature of biomedical signals – Objectives of biomedical signal analysis – difficulties in bio medical signal analysis – Noises – Random – Structured and Physiological noises – Filters – Time domain filters and frequency domain filters.

Module:2	**Spectrum Analysis**	**4 hours**

Detection of Events and Waves – Derivative-based methods for QRS detection – Pan-Tompkins algorithm for QRS detection – Cross Spectral techniques and Coherence analysis of EEG signals – Matched filters – Homomorphic filtering.

Module:3	**Time Series Analysis**	**4 hours**

Time series analysis – Characterization of nonstationary signals and dynamic systems – Non- stationary process – Fixed segmentation – Adaptive segmentation – RLS Lattice filter – Application in EEG, PCG signals – Time varying analysis of Heart-rate variability.

Module:4	**Frequency Domain characterization**	**4 hours**

The Fourier Spectrum – Estimation of the Power Spectral Density Function Measures Derived from PSDs – Parametric System Modeling – Autoregressive or All-pole Modeling – Application in HRV, PCG signals.

Module:5	**Adaptive Filtering**	**4 hours**

Optimal Filtering – The Wiener Filter – Adaptive Filters for Removal of Interference in FECG – Improved adaptive filters in FECG – Application in muscle contraction interference.

Module:6	**Wavelets and Bio signal Classification**	**4 hours**

Discrete wavelet transform – Short time Fourier transform and spectrogram – Dyadic wavelet transform – multiresolution signal decomposition – Wavelet packets – Signal Pattern Classification – Probabilistic Models and Statistical Decision – Logistic Regression Analysis.

Module:7	**Time Frequency and Multivariate Analysis**	**5 hours**

Back propagation neural network based classification – Application in Normal versus Ectopic ECG beats – Measures of Diagnostic Accuracy and Cost – Multivariate component analysis – PCA – ICA – Application in Detection of Knee-joint Cartilage Pathology.

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1. Rangaraj.M.Rangayyan, “Biomedical Signal Analysis”, 2nd edition 2016, IEEE press, New York.

Reference Books

1.	Katarzyna J. Blinowska and Jaroslaw Zygierewicz, “Practical biomedical signal analysis using MATLAB”, 2nd edition, CRC press 2022, Florida.		
2.	Sri Krishnan, “Biomedical signal analysis for connected healthcare” 1st edition 2021, Academic Press Elsevier, United Kingdom.		
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
BBMD202P	Bio Signal Analysis Lab	0	0	2	1
Pre-requisite	BECE202L	Syllabus version			
		1.0			

Course Objectives

1. To understand the fundamentals of biomedical signal acquisition and signal classification.
2. To impart knowledge about physiological signal processing and analysis.
3. To apply adaptive filtering techniques for cancelling noise and interference in the various bio-signals.

Course Outcome

1. Evaluate the classification of bio signals using wavelets.
2. Demonstrate the feature reduction methods for different bio signals.

Indicative Experiments

1.	Acquire two ECG samples from same and two different individuals. Perform correlation between the samples. Tabulate and interpret the results.	**6 hours**
2.	Acquire the ECG signal and add 60 Hz sine wave to it. Plot the PSD to show the noise on the mixed signal. Design an appropriate filter to remove the noise and plot the PSD of the filtered signal to show that noise is removed. Explain the design aspect of the filter.	**6 hours**
3.	Acquire 4 channel simultaneously recorded EEG signals with spike and wave complexes. Cut out spike and wave complex from any one of the channel and keep it as template. Perform template matching. i) Same channel when the template is selected ii) Other channels	**6 hours**
4.	Process a bio-signal and extract higher order statistical feature using ICA from it. Using PCA obtain significant features of it. Apply supervised learning method to classify the bio-signal.	**6 hours**
5.	Record your own speech in three different media and compare the speech signals. Estimate the h(n) of your two medias (different mobiles) by assuming one of them as your x(n). Use a linear approach in obtaining the result 1 and use deconvolution to obtain the result 2 and compare both the results.	**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
BBMD203L	Medical Image Analysis	2	0	0	2
Pre-requisite	BECE301L, BECE301P	Syllabus version			
		1.0			

Course Objectives

1. To discuss digital image fundamentals and image enhancement techniques.
2. To discover the principles filtering techniques in spatial domain and frequency domain forenhancement and restoration.
3. To identify the segmentation techniques for feature extraction from images and classification.
4. To formulate image registration techniques and virtual reality.

Course Outcome

Student is expected to:

1. Analyze and enhance digital images by spatial and frequency domain methods.
2. Apply filtering techniques to images for noise removal and restoration.
3. Formulate segmentation algorithms to extract features and classify the images.
4. Analyze different registration techniques from different modalities and visualization.
5. Develop algorithms to solve specific problems faced by health care professionals.

Module:1	**Digital Image and Transforms**	**2 hours**
Modulating transfer function of visual system - Digitizing an image - medical image formats - image quality and information content- histogram – entropy - Fourier Transform and spectral contents- Signal-to-Noise-Ratio.		
Module:2	**Removal of Noise in Medical Images**	**5 hours**
Noise characterization- multi-frame averaging - statistics based filters - frequency domain filters for high frequency noise and periodic noise removal- Wiener filter- adaptive filters.		
Module:3	**Medical Image Enhancement**	**5 hours**
Digital subtraction angiography - gray scale transforms - Histogram transformation - convolution mask operators-high frequency emphasis - homomorphic filtering - contrast enhancement.		
Module:4	**Image Restoration**	**3 hours**
Modelling image degradation - Inverse filtering - Wiener filtering - motion deblurring - blind deblurring.		
Module:5	**Medical Image Analysis and Classification**	**5 hours**
Image segmentation - pixel based - edge based and region based - morphological operations - Representation of shapes and contours - shape factors - statistical analysis of texture - Feature extraction and image classification - statistical - rule based and neural network approaches.		
Module:6	**Image Compression**	**3 hours**
Lossy Vs lossless compression - distortion measures and fidelity criteria - Direct source coding - transform coding - predictive coding - Image coding and compression standards.		
Module:7	**Image Registration and Visualization**	**5 hours**
Image registration - Rigid body transformation - Principal axis registration, Interactive principal axis registration - Feature based registration - Elastic deformation based registration - Image visualization - Surface rendering - volume rendering - virtual reality.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	Atam P Dhawan, Medical Image Analysis, 2011, 2nd edition, Wiley, Oxford.		
2.	Rafael C. Gonzales, Richard E. Woods, "Digital Image Processing", 2018, 4th edition, Pearson Education, New York.		
Reference Books			
1.	Anil Jain K. "Fundamentals of Digital Image Processing", 2011, 1st edition, Prentice Hall India Learning Pvt. Ltd, Delhi.		
2.	William K Pratt, "Digital Image Processing", 2013, 1st edition, CRC Press, Florida.		
3.	G Dougherty, "Medical Image Processing Techniques and Applications", 2011, Springer, ISBN: 978-1-4419-9779-1		
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
BBMD203P	Medical Image Analysis Lab	0	0	2	1
Pre-requisite	BECE301L, BECE301P	Syllabus version			
		1.0			

Course Objectives

1. To discover the principles filtering techniques in spatial domain and frequency domain forenhancement and restoration.
2. To identify the segmentation techniques for feature extraction from images and classification.
3. To formulate image registration techniques and virtual reality.

Course Outcome

1. Develop algorithms to solve the given problems.
2. Design and Conduct experiments individually and as a team and report the outcome.

Indicative Experiments

1.	Read the given x-ray image using Matlab software and perform contrast enhancement and remove the noise using spatial low pass filters. Compare their performance.	**6 hours**
2.	Read the CT image of the given lungs image, perform intensity enhancement, and extract the nodules in the lungs using Matlab software.	**6 hours**
3.	Segment the white matter, gray matter and CSF from the given MRI image using Matlab software.	**6 hours**
4.	Process the given endoscopic images and extract the tumor detected using Matlab software.	**6 hours**
5.	Extract the blood vessels from the given retinal image using Matlab software.	**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
BBMD204L	Medical Imaging Techniques	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To analyze the production of x-rays and summarize its application in medical imaging.
2. To analyze and apply different types of Radio diagnostic techniques and suitable specific applications.
3. To analyze and apply the suitable special imaging techniques used for visualizing the cross sections of the body.

Course Outcome

The student will be able to

1. Apply knowledge of physics and Engineering to understand the acquisition techniques involved in different X Ray medical imaging.
2. Analyze the principle of interaction of nuclei in magnetic resonance imaging and functions of various magnet imaging components.
3. Apply and analyze the application emission imaging for diagnostics applications.
4. Analyze Ultrasound imaging and thermal imaging, and choose the appropriate for specific applications.
5. Choose an appropriate case study implementation from the domain of medical image and effectively evaluate its various aspects using the tools learnt.

Module:1	**X – Rays**	**6 hours**
X-Rays - Interaction with matter - X-ray detectors- Dual-energy imaging – Image quality - Equipment - Clinical use- Biologic effects and safety- Future expectations – Calibration.		
Module:2	**Computed Tomography**	**6 hours**
X-ray detectors in CT - Imaging – Cardiac CT -Dual-energy CT- Image quality - Equipment - clinical use- Biologic effects and safety- Future expectations – Calibration.		
Module:3	**Magnetic Resonance Imaging**	**6 hours**
Physics of the transmitted signal - Interaction with tissue – Signal detection and detector – Imaging – Image quality - Equipment - clinical use- Biologic effects and safety- Future expectations– Calibration.		
Module:4	**Nuclear medicine imaging**	**6 hours**
Radionuclides- Interaction of γ-photons and particles with matter - Data acquisition – Imaging - Image quality - Equipment - clinical use- Biologic effects and safety- Future expectations– Calibration.		
Module:5	**Ultrasound Imaging**	**7 hours**
Physics of acoustic waves- Generation and detection of ultrasound - Gray scale imaging - Doppler imaging- Image quality - Equipment - clinical use- Biologic effects and safety- Future expectations – Calibration.		
Module:6	**Thermography**	**6 hours**
Heat Exchange and Infrared radiation - Detectors – Lenses used in the infrared cameras – Image Acquisition – Image display – The thermal image – Image Capture – Image Evaluation– Calibration.		
Module:7	**Visualization for diagnosis and therapy**	**6 hours**
2D visualization - 3D rendering - Virtual reality - User interaction - Intraoperative navigation - Augmented reality - Future expectations		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)			
1.	Paul Suetens, “Fundamentals of Medical Imaging”, 2017, 3rd edition, Cambridge UniversityPress, Cambridge, New York.		
2.	Kurt Ammer , Francis Ring, “The Thermal Human Body: A Practical Guide to Thermal Imaging”, 2019, Jenny Stanford Publishing Pte. Ltd, Singapore.		
Reference Books			
1.	Gopal B.Saha, “Physics and Radiobiology of Nuclear Medicine”, 2013, 4th edition Springer- Verlag, New York		
2.	Russell K. Hobbie, Bradley J. Roth, “Intermediate Physics for Medicine and Biology”, 2015, 5th edition Springer International Publishing, Switzerland.		
Mode of Evaluation: Continuous Assessment Test, Quiz, Digital Assignment, Final AssessmentTest			
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
BBMD205L	Biomaterials	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To discuss about the basic fundamentals of biomaterials with its classification.
2. To discover various properties of biomaterials and its significance in healthcare industry.
3. To identify the process involved in design and development of various artificial organs and its importance.

Course Outcome

The student will be able to

1. Analyze and classify the different properties and classification of biomaterials.
2. Evaluate the design constraints of artificial organs and its outlook for organ replacement.
3. Design and develop the need for appropriate considerations in different types of artificial organs like kidney, heart, lungs, liver and blood.
4. Apply ethical concepts in designing the artificial organs for healthcare industry.
5. Diagnose the need for the preparation and ability to engage in independent and life-long learning for technological updates in artificial organs.

Module:1	**Structure and properties of Materials**	**6 hours**
Introduction to Biomaterials Science – Properties of Materials – The nature of Matter and Materials – Bulk Properties of Materials – Surface Properties and Surface Characterization of Biomaterials – Role of Water in Biomaterials.		
Module:2	**Classes of Materials used in Medicine**	**8 hours**
The Materials side of the biomaterials relationship – Polymers – Polyurethanes – Hydrogels – Degradable and resorbable polymers – Metals – Titanium alloys – Stainless steel – CoCr alloys – Biodegradable metals – Ceramics – Glasses and Glass ceramics.		
Module:3	**Host Reaction to Biomaterials and their evaluation**	**5 hours**
Biological Responses to Materials – Inflammation – Wound healing – Foreign body response and alternative tissue responses – Innate and adaptive Immunity – Blood coagulation and Blood Material interactions – Tumorigenesis - Biofilms and Device related infections.		
Module:4	**Characterization of Biomaterials**	**6 hours**
Concept and assessment of Biocompatibility – *In vitro* and *In vivo* assessment of cell and tissue compatibility – Evaluation of Blood materials interactions – Physical – chemical – mechanical characterization techniques used for biomaterials.		
Module:5	**Applications of Biomaterials**	**6 hours**
Cardiovascular medical devices – Heart valves – Mechanical circulatory support – Stents – Grafts – Orthopedic applications – Dental applications – Ophthalmologic applications – Burn dressings and skin substitutes.		
Module:6	**Artificial Cells and Extracorporeal Artificial organs**	**6 hours**
Basic features of artificial cells – Research into the application of artificial cells Artificial cells in Hemoperfusion – Artificial cells containing stem cells in regenerative medicine.		
Module:7	**Biomaterial applications in Artificial organs**	**6 hours**
Repair of skeletal tissues – Joint replacement – Artificial organs – Mass transport processes in artificial organs – Artificial exchange systems.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	William Wagner, Shelly Sakiyama-Elbert, Guigen Zhang, Michael Yaszemski, Biomaterials Science - An Introduction to Materials in Medicine, 2020, 4th edition, Elsevier Science.			
2.	Michael Lysaght, Thomas J Webster, Biomaterials for Artificial Organs, 2018, 1st edition, Elsevier Science.			
Reference Books				
1.	Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, Biomaterials Science., 2013, 3rd edition, Academic Press, Elsevier Science.			
2.	Gerald E. Miller, Artificial Organs – Synthesis lectures on Biomedical Engineering., 2006, 1st edition, Morgan and Claypool Publishers.			
3.	Hench Larry L (Ed)., Biomaterials artificial organs and tissue engineering., 2005, 1st edition., Woodhead Publishing Limited.			
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
BBMD206L	Biomechanics	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. Introduce the basic concepts of solid mechanics and fluid dynamics with respect to physiological systems.
2. Familiarize students with the mathematical models that can be used in the analysis of physiological systems.
3. Understand the parameters and constraints pertaining to the designing of the physiological tissues and organs.

Course Outcome

1. To interpret the basic concepts of mechanics and fluid dynamics in human body.
2. To realize the effect of abnormal posture, its influences on gait and role of ergonomics.
3. To develop better acquaintance about various bio fluids.
4. To model any solid/ fluid tissue and their interactions.
5. To explore various parameters and constraints in FEM and FEA of solid and fluid bio structures.

Module:1	Biomechanics of joint structure and function	9 hours

Kinematics and Kinetics – Descriptions of Motion – Forces – Statics and Dynamics – Translatory Motion in Linear and Concurrent Force Systems – Additional Linear Force Considerations – Torque or Moment of Force – Muscle Forces – Lever Systems or Classes of Levers – Joint Structure and Function – Joint Design – Materials Used in Human Joints – General Properties of Connective Tissue – Complexities of Human Joint Design – Joint Function – General Changes with Disease – Injury – Immobilization – Exercise – Overuse.

Module:2	Muscle Structure and Function	5 hours

Elements of Muscle Structure – Muscle Function – Effects of Immobilization – Injury – Aging

Module:3	Integrated Function and Ergonomics	8 hours

Posture – Static and Dynamic Postures – Kinetics and Kinematics of Posture – Optimal Posture – Analysis of Standing Posture – Sitting Postures – Lying Postures – Effects of Age – Pregnancy – Occupation and Recreation on Posture – Gait – Kinematics and Kinetics – Stair and Running Gaits – Effects of Age – Gender – Assistive Devices and Orthoses – Abnormal Gait – Ergonomics.

Module:4	Constitutive Equation	7 hours

Stress – Strain – Strain Rate – Constitutive Equations – NonViscous Fluid – Newtonian Viscous Fluid – Hookean Elastic Solid – Effect of Temperature – Materials with More Complex Mechanical Behavior – Viscoelasticity – Use of Viscoelastic Models – Response of a Viscoelastic Body to Harmonic Excitation – Methods of Testing.

Module:5	Flow Properties of Blood	5 hours

Blood Rheology: An Outline – Laminar Flow of Blood in a Tube – Fluid-Mechanical Interaction of Red Blood Cells – Thrombus Formation and Dissolution – Medical Applications of Blood Rheology.

Module:6	Bioviscoelastic Fluids	3 hours

Newton's ring – Methods of Testing and Data Presentation – Protoplasm – Mucus from the Respiratory Tract – Cervical Mucus and Semen – Saliva – Synovial Fluid.

Module:7	Mechanical Remodeling of Tissues	6 hours

Active Remodeling of Blood vessel – Skeletal muscle: Hill's Three-Element Model – Heart Muscle – Smooth Muscles: Ureter – Bone and Cartilage – modeling using software – concepts of Finite Element Modeling and Finite Element Analysis.

Module:8	Contemporary Issues	2 hours

	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Pamela K Levangie and Cynthia C Norkins, Joint Structure and Function: A Comprehensive Analysis, 2019, 6th Edition, F. A. Davis Company, USA.
2.	Y C Fung, Biomechanics – Mechanical Properties of Living Tissue, 2016, 2nd Edition, Spinger, USA.
Reference Books	
1.	R S Bridger, Introduction to Human Factors and Ergonomics, 2018, 4th Edition, CRS Press Taylor and Francis Group, USA.
2.	Singiresu S Rao, The Finite Element Method in Engineering, 2019, 6th Edition, Elsevier, 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
BBMD207L	Hospital Management	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. With an objective of imbibing a professional approach amongst students towards hospitalmanagement.
2. The subject encompasses management principles, staffing and marketing processes, discussing their significance and role in effective and efficient management of health care organizations.

Course Outcome

The student will be able to

1. Define basic principles of science and engineering in management of hospitals.
2. Create, select and apply appropriate computer based technologies and IT tools for hospital management.
3. Define and demonstrate appropriate techniques in the disposal and hospital waste management mechanisms including modern engineering solutions for waste disposal.
4. Demonstrate electrical and fire safety measures for in public health and safety in hospitals.
5. Demonstrate the knowledge and importance of quality in healthcare in particular hospitals for societal and environmental sustainability.
6. Define and analyze the material and legal aspects in hospitals and write effective reports, design documentation and make effective presentations.

Module:1	Hospital Management Principles and Practice	6 hours

Importance of management and Hospital-Management control systems-Forecasting techniques decision-making process-Staffing pattern in hospitals-Selection-Recruiting Process-Training of staff- Organizational structures.

Module:2	Medical Records	6 hours

System Development life cycle-Reasons to use computers in hospital-Main categories of informationsystems in hospitals-EPR-E health care, EMR, EHR and CCR.

Module:3	Infection control and waste disposal	6 hours

Disease Transmission - Disinfection methods – Sterilization - steam sterilizing (Autoclaving) - Microwave (Non-burn treatment technology)-Disposal methods - Incinerator - Hazardous waste- Radioactive Waste-Liquid waste destruction landfill-Air pollution and Emission control-Instrumentation and monitoring-Crematories.

Module:4	Hazard recognition	6 hours

Sources of shocks, macro & micro shocks-Hazards, monitoring and interrupting the operation from leakage current- Elements of fire-causes of fire-Action to be taken in case of fire in a hospital.

Module:5	Quality Management, Codes and Acts	6 hours

ICMR Code for biomedical research-pharmacy act-medical device regulation act-Indian medical council act-Quality council of India-National medical commission-drug and cosmetics act-environmental protection-Transplantation of human organ act - ISO and Six Sigma in hospitals.

Module:6	Stores and Biomedical equipment management	7 hours

Classification of Materials-Purchase Management- Purchase system (Centralized, Decentralized, Local purchase-Purchase Procedures: -Selection of Suppliers-Tendering Procedures-Analyzing Bids-Pricenegotiations-Issue of purchase orders-Rate Contracts-Follow up action-Biomedical equipment classification-procurement and maintenance.

Module:7	**Laws related to healthcare**	**6 hours**
Medico legal aspects-Preventive Steps for Doctors/Hospitals to Avoid Litigation-Consent Form-Life Support Dying Declaration-Death Certificate-Post Mortem		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**44 hours**

Text Book(s)	
1.	Subrahmanyam B.V., “Hospital management and administration principles and practice including law” (2018), CBS Publication.
Reference Books	
1.	Hospital Management, K. V. Ramani, 1st edition, Pearson Education India, 2011.
2.	Hospital Administration and Management: A Comprehensive Guide, Gupta Joydeep Das, Jaypee Brothers Medical Publishers; second edition, 2015.

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
BBMD208L	Telemedicine and Telecare	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To impart the key principle of telemedicine and healthcare.
2. Expound element of tele systems like image acquisition system, display system andcommunication networks.
3. To enable the students with the knowledge of tele medical standards, mobile telemedicine and its applications.

Course Outcome

Student will be able to:

1. Apply multimedia technologies in telemedicine.
2. Recognize the need for tele medical data security and standards.
3. Design mobile telemedicine in telehealth care.
4. Analyze the importance of digital imaging and picture archiving and communication systems in telemedicine application.
5. Realize the human machine interfaces for teleoperation cooperation manipulation.

Module:1	Telemedicine Systems	7 hours

Telemedicine - Biomedical telemetry- History of telemedicine – telemedicine technology- benefits of telemedicine – types of telemedicine service – Delivery mechanisms in telemedicine- challenges in implementing telemedicine- Standards and guidelines. Telemedicine system – essential parameters – components – Trends – Delivery modes – setting up a telemedicine facility - Ethical and legal aspects of Telemedicine.

Module:2	Technology of Telemedicine systems	6 hours

Telemedicine Technology – Data transmission – Transmission of still images – Transmission of video – transmission of Audio – Hardware platform and workstation for telemedicine – computer networking configuration – Telemedicine software – Interfacing medical devices to computers.

Module:3	Telecommunication Technologies	6 hours

Telecommunications types – Internet as communication medium – Options for Telecommunication selection – Computer networking in hospitals – Network configurations – Network topologies – Network management in telemedicine- Open system interconnection model – Wide Area Network implementation – Wireless technologies for telemedicine - Antennas for telemedicine applications – Operational issues in telemedicine.

Module:4	Mobile Health and Tele care	6 hours

Technologies of mHealth - Wireless connectivity - Ubiquitous healthcare - Wireless networks (WBAN-WPAN-WSN) - mHealth in Intensive care monitoring – Mobile Telemedicine – Tele home care – Categories - Technologies – Requirements – Chronic Disease Management – Health and Fitness – Challenges in Tele home care.

Module:5	Telemedical Standards	6 hours

Personal Health monitors – Data standards – eHealth service security and interoperability – Cyber Medicine – Videoconferencing system – Components – Categories – Network consideration – Videoconferencing over Internet – Multipoint system – Video conferencing standards (H.320-H.323-H.324-H.261-T.120)

Module:6	Mobile Telemedicine	6 hours

Application of Telemedicine – Tele radiology - Definition, Basic parts of tele radiology system - Image Acquisition system - Display system – Picture archiving and Communication systems (PACS) - Tele pathology -Multimedia databases - Color images of sufficient resolution - Dynamic range - Spatial resolution - Compression methods - Interactive control of color.

Module:7	**Telemedical Applications**	**6 hours**
Telemedicine access to health care services - Health education and self-care - Introduction to Telecardiology - Teleoncology – Tele surgery – Telementoring – Robot assisted surgery – Telepresence – Telerehabilitation.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	R.S. Khandpur, Telemedicine technology and applications (mHealth, Telehealth and eHealth), 2017, PHI Publications ltd.
Reference Books	
1.	A. C. Norris, Essentials of Telemedicine and Telecare, 2002,1st Edition John Wiley & Sons, Ltd.
2.	Bernard Fong, A.C.M. Fong, C.K. Li, Telemedicine Technologies: Information Technologies in Medicine and Telehealth, 2020, 2nd edition, John Wiley & Sons Ltd, New York.

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
BBMD209L	Health Informatics	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. Introduce the basic concepts in Biomedical Informatics.
2. Understand the applications of an electronic medical record system and medical standards.
3. Acquaint the students to clinical decision support systems
   Introduce the basics of bioinformatics, resources in the field and explore the various databases.

Course Outcome

Students will be able to

1. State and define origin and importance of Health informatics.
2. Describe the healthcare data and tools for data analytics.
3. Demonstrate the knowledge and importance medical standards and coding.
4. Define and demonstrate key components of HER and mobile technology.
5. Identify and interpret various bioinformatics tools and databases.
6. Define and identify importance of health information ethics and laws.

Module:1	**Health Informatics**	**6 hours**
Informatics definitions-Historical highlights-Key players in health information technology-Organizations involved with HIT-Barriers to hit adoption-Health informatics resources.		
Module:2	**Healthcare Data, Information and Analytics**	**6 hours**
Definitions And Concepts-Converting Data To Information to Knowledge-Clinical Data Warehouses (CDWS)- Terminology of Analytics-Challenges to Data Analytics-Role Of Informaticians In Analytics-Research and Application of Analytics.		
Module:3	**Data Standards, Coding and Architechure**	**6 hours**
Content, Terminology And Transport Standards- Medical Coding- The Internet And World Wide Web- Web Services-Network- HIPAA- Basic Security Principles- Data Security In the Cloud And Client/Server Solutions.		
Module:4	**Electronic Health Records**	**6 hours**
Need For Electronic Health Records-Vision For EHRS-Electronic Health Record Key Components-Computerized Physician Order Entry (CPOE)-Clinical Decision Support Systems (CDSS)- Electronic Prescribing-Electronic Health record adoption and Challenges.		
Module:5	**Mobile Technology**	**6 hours**
History Of Mobile Technology-Mobile Health (Mhealth)- Mobile Technology And Patients-Mobile Technology And Clinicians-Mobile Technology To Track Health Habits.		
Module:6	**Bioinformatics**	**6 hours**
Importance of Bioinformatics -Genomic Primer - Bioinformatics Projects and Centers (NCBI) - Personal Genomics (Human Genome Project) – Genomic Information Integrated with EHRS.		
Module:7	**Health Informatics Ethics**	**7 hours**
Informatics Ethics- International Considerations: Ethics, Laws And Culture Codes of Individual Countries- Pertinent Ethical Principles- Difficulties Applying Medical Ethics In The Digital World- Electronic Communication With Patents And Caregivers -Transferring Ethical Responsibility- Health Informatics Ethics and Medical Students		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)			
1.	Robert e. Hoyt, “Health Informatics” Practical Guide for Healthcare and Information Technology. Seventh Edition, 2018, Electronic edition.		
Reference Books			
1.	Rastogi, “Bioinformatics: Methods and Applications: Genomics, Proteomics And Drug Discovery”, 2013, 4th edition, Prentice Hall, New Delhi.		
2.	Edward H. Shortliffe and James J. Cimino, “Biomedical Informatics: Computer Applications in Health Care and Biomedicine (Health Informatics)”, 2014, 4th edition, Springer, New York.		
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
BBMD210L	Medical Robotics	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To study the kinematics, dynamics and various motion planning and control of robotics.
2. To understand the importance of medical automation and medical robotics.
3. To learn about prospective robotic systems for potential surgical interventions.

Course Outcome

1. Have an understanding of the basics of robotics.
2. Discover the kinematics and dynamic involved in design of robotic systems.
3. Determine the path and plan a trajectory for a mobile system.
4. Understand the importance of robotics in the field of surgery.
5. Focus on future trends on medical robotics.

Module:1	**Robot assisted minimally invasive surgery**	**7 hours**
Introduction, Minimally invasive surgery and robotic integration, development of surgical robotics systems, Perceptual docking for synergistic control, future scope, Localization and tracking technologies for medical robotics - Requirements for position sensors, Dynamic referencing, Types of position sensors.		
Module:2	**Robotics for neurosurgery and cardiovascular interventions**	**7 hours**
Introduction to neurosurgical progression, Evolution of neurosurgical robots, Maintaining operator Control, Human machine interface, Future trends: informatics surgery Introduction to Heart conditions and evolving role of cardiac surgeons and cardiologists, surgical robot requirements and availability for cardiovascular interventions, Future trends.		
Module:3	**Robotics in Orthopaedic and Knee replacement surgery**	**7 hours**
Introduction, existing orthopedic robotic systems, evaluation of impact of orthopedic surgical robots-Knee replacement surgery, Apex Robotic Technology (ART), Challenges and future scope.		
Module:4	**Robotics in ear, nose, throat (ENT)and vitreoretinal surgery**	**7 hours**
Telemanipulators in ENT- Image-guided interventions - Computer numerical control (CNC)- Requirements for vitreoretinal surgery- Master console - Slave robot.		
Module:5	**Robotics for transluminal endoscopic surgery and gastrointestinal minimally invasive surgery (MIS)**	**7 hours**
Minimally invasive surgery (MIS) - Natural orifice transluminal endoscopic surgery (NOTES)- Commercial gastrointestinal wireless capsule endoscopes- Robotic capsule modules.		
Module:6	**Magnetic microrobots**	**4 hours**
Magnetic resonance imaging (MRI) navigation - Microrobot navigation -		
Module:7	**Robotic surgery and ethical challenges**	**4 hours**
Types of robotic surgery - Comparing robotic surgery with other types of surgery - Ethical issues relating to remotely operated surgery - The automated hospital.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)			
1.	Paula Gomes, “Medical Robotics: Minimally Invasive Surgery”, 1st Edition, Woodhead Publisher, UK, 2012.		
Reference Books			
1.	John J. Craig, “Introduction to Robotics, Mechanics and Control”, Pearson Education, 3rd Edition, 2010.		
2.	Mikell P. Groover, “Industrial Robotics: Technology, Programming and Applications”, McGraw-Hill Publishers, 2nd Edition, 2012.		
3.	Jaydev P Desai, “The Encyclopedia of Medical Robotics: Vol 1&2”, World Scientific, 2018.		
4.	JocelyneTroccaz, “Medical Robotics”, 1st edition, Wiley, USA, 2013.		
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