VIT®

Vellore Institute of Technology

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

## SCHOOL OF ELECTRONICS ENGINEERING

# B. Tech Electronics and Communication Engineering

Curriculum

(***2023-24*** *admitted students*)

## VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research.

## MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

**World class Education**: Excellence in education, grounded in ethics and critical thinking, for improvement of life.
**Cutting edge Research**: An innovation ecosystem to extend knowledge and solve critical problems.
**Impactful People**: Happy, accountable, caring and effective workforce and students.
**Rewarding Co-creations**: Active collaboration with national & international industries & universities for productivity and economic development.
**Service to Society**: Service to the region and world through knowledge and compassion.

## VISION STATEMENT OF THE SCHOOL OF ELECTRONICS ENGINEERING

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

## MISSION STATEMENT OF THE SCHOOL OF ELECTRONICS ENGINEERING

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

## B. Tech Electronics and Communication Engineering

# PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

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

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

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

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

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

6. Graduates will pursue career paths in teaching or research

## B. Tech Electronics and Communication Engineering

# PROGRAMME OUTCOMES (POs)

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

**PO_02. Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

**PO_03. Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

**PO_04. Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

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

**PO_06. The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

**PO_07. Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

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

**PO_10. Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

**PO_11. Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles, and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

**PO_12. Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

# B. Tech Electronics and Communication Engineering

## PROGRAMME SPECIFIC OUTCOMES (PSOs)

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

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

**PSO_02.** Design and develop the communication systems for various applications

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

## Category Credit Detail

| Sl.No. | Description | Credits | Maximum Credit |
|---|---|---|---|
| 1 | FC - Foundation Core | 49 | 49 |
| 2 | DLES - Discipline-linked Engineering Sciences | 10 | 10 |
| 3 | DC - Discipline Core | 53 | 53 |
| 4 | DE - Discipline Elective | 9 | 15 |
| 5 | PI - Projects and Internship | 9 | 9 |
| 6 | OE - Open Elective | 0 | 15 |
| 7 | BC - Bridge Course | 0 | 0 |
| 8 | NGCR - Non-graded Core Requirement | 11 | 11 |
| 9 | ME - Multidisciplinary Elective | 0 | 21 |
| **Total Credits** | | 162 | |
| **Combined Category** | | DE + OE + ME \| Credit Min.: 30 \| Credit Max.: 30 | |

## 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 | BEEE102L | Basic Electrical and Electronics Engineering | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 6 | BEEE102P | Basic Electrical and Electronics Engineering Lab | Lab Only | 1.0 | 0 | 0 | 2 | 0 | 1.0 |
| 7 | BENG101L | Technical English Communication | Theory Only | 1.0 | 2 | 0 | 0 | 0 | 2.0 |
| 8 | BENG101P | Technical English Communication Lab | Lab Only | 1.0 | 0 | 0 | 2 | 0 | 1.0 |
| 9 | BENG102P | Technical Report Writing | Lab Only | 1.0 | 0 | 0 | 2 | 0 | 1.0 |
| 10 | BFLE200L | B.Tech. Foreign Language - 2021onwards | Basket | 1.0 | 0 | 0 | 0 | 0 | 2.0 |
| 11 | BHSM200L | B.Tech. HSM Elective - 2021 onwards | Basket | 1.0 | 0 | 0 | 0 | 0 | 3.0 |
| 12 | BMAT101L | Calculus | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 13 | BMAT101P | Calculus Lab | Lab Only | 1.0 | 0 | 0 | 2 | 0 | 1.0 |
| 14 | BMAT102L | Differential Equations and Transforms | Theory Only | 1.0 | 3 | 1 | 0 | 0 | 4.0 |
| 15 | BMAT201L | Complex Variables and Linear Algebra | Theory Only | 1.0 | 3 | 1 | 0 | 0 | 4.0 |
| 16 | BMAT202L | Probability and Statistics | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 17 | BMAT202P | Probability and Statistics Lab | Lab Only | 1.0 | 0 | 0 | 2 | 0 | 1.0 |
| 18 | BPHY101L | Engineering Physics | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 19 | BPHY101P | Engineering Physics Lab | Lab Only | 1.0 | 0 | 0 | 2 | 0 | 1.0 |
| 20 | BSTS101P | Quantitative Skills Practice I | Soft Skill | 1.0 | 0 | 0 | 3 | 0 | 1.5 |
| 21 | BSTS102P | Quantitative Skills Practice II | Soft Skill | 1.0 | 0 | 0 | 3 | 0 | 1.5 |
| 22 | BSTS201P | Qualitative Skills Practice I | Soft Skill | 1.0 | 0 | 0 | 3 | 0 | 1.5 |
| 23 | 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 | BECE317L | Wireless and Mobile Communications | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 21 | BECE317P | Wireless and Mobile Communications Lab | Lab Only | 1.0 | 0 | 0 | 2 | 0 | 1.0 |
| 22 | BECE318L | Optical Fiber Communications | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 23 | BECE318P | Optical Fiber Communications Lab | Lab Only | 1.0 | 0 | 0 | 2 | 0 | 1.0 |
| 24 | BECE401L | Computer Communications and Networks | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 25 | BECE401P | Computer Communications and Networks Lab | Lab Only | 1.0 | 0 | 0 | 2 | 0 | 1.0 |

### Discipline Elective

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

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

| Projects and Internship | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| sl.no | Course Code | Course Title | Course Type | Version | L | T | P | J | 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 | BCHE202L | Chemical Engineering Thermodynamics | Theory Only | 1.0 | 3 | 1 | 0 | 0 | 4.0 |
| 2 | BECE355L | Advanced Cloud Computing | Theory Only | 2.0 | 3 | 0 | 0 | 0 | 3.0 |
| 3 | BEEE201L | Electronic Materials | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 4 | BEEE203L | Circuit Theory | Theory Only | 1.0 | 3 | 1 | 0 | 0 | 4.0 |
| 5 | BHUM111L | Happiness and Well-being | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 6 | BHUM201L | Mass Communication | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 7 | BHUM202L | Rural Development | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 8 | BHUM203L | Introduction to Psychology | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 9 | BHUM204L | Industrial Psychology | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 10 | BHUM205L | Development Economics | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 11 | BHUM206L | International Economics | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 12 | BHUM207L | Engineering Economics | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 13 | BHUM208L | Economics of Strategy | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 14 | BHUM209L | Game Theory | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 15 | BHUM210E | Econometrics | Embedded Theory and Lab | 1.0 | 2 | 0 | 2 | 0 | 3.0 |
| 16 | BHUM211L | Behavioral Economics | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 17 | BHUM212L | Mathematics for Economic Analysis | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 18 | BHUM213L | Corporate Social Responsibility | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 19 | BHUM214L | Political Science | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 20 | BHUM215L | International Relations | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 21 | BHUM216L | Indian Culture and Heritage | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 22 | BHUM217L | Contemporary India | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 23 | BHUM218L | Financial Management | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 24 | BHUM219L | Principles of Accounting | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 25 | BHUM220L | Financial Markets and Institutions | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 26 | BHUM221L | Economics of Money, Banking and Financial Markets | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 27 | BHUM222L | Security Analysis and Portfolio Management | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 28 | BHUM223L | Options , Futures and other Derivatives | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 29 | BHUM224L | Fixed Income Securities | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 30 | BHUM225L | Personal Finance | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 31 | BHUM226L | Corporate Finance | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 32 | BHUM227L | Financial Statement Analysis | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 33 | BHUM228L | Cost and Management Accounting | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 34 | BHUM229L | Mind, Embodiment and Technology | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 35 | BHUM230L | Health Humanities in Biotechnological Era | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 36 | BHUM231L | Reproductive Choices for a Sustainable Society | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 37 | BHUM232L | Introduction to Sustainable Aging | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 38 | BHUM233L | Environmental Psychology | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |
| 39 | BHUM234L | Indian Psychology | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 |

## Open Elective

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|---|---|---|---|---|---|---|---|---|---|---|
| 40 | BHUM235E | Psychology of Wellness | Embedded Theory and Lab | 1.0 | 2 | 0 | 2 | 0 | 3.0 | |
| 41 | BHUM236L | Taxation | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 | |
| 42 | BMEE102P | Engineering Design Visualisation Lab | Lab Only | 1.0 | 0 | 0 | 4 | 0 | 2.0 | |
| 43 | BMEE201L | Engineering Mechanics | Theory Only | 1.0 | 2 | 1 | 0 | 0 | 3.0 | |
| 44 | BMEE203L | Engineering Thermodynamics | Theory Only | 1.0 | 2 | 1 | 0 | 0 | 3.0 | |
| 45 | BMGT108L | Entrepreneurship | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 | |
| 46 | BMGT109L | Introduction to Intellectual Property | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 | |
| 47 | BPHY201L | Optics | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 | |
| 48 | BPHY202L | Classical Mechanics | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 | |
| 49 | BPHY203L | Quantum Mechanics | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 | |
| 50 | BPHY301E | Computational Physics | Embedded Theory and Lab | 1.0 | 2 | 0 | 2 | 0 | 3.0 | |
| 51 | BPHY302P | Physics Lab | Lab Only | 1.0 | 0 | 0 | 2 | 0 | 1.0 | |
| 52 | BPHY401L | Solid State Physics | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 | |
| 53 | BPHY402L | Electromagnetic Theory | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 | |
| 54 | BPHY403L | Atomic and Nuclear Physics | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 | |
| 55 | BPHY404L | Statistical Mechanics | Theory Only | 1.0 | 3 | 0 | 0 | 0 | 3.0 | |
| 56 | BSTS301P | Advanced Competitive Coding - I | Soft Skill | 1.0 | 0 | 0 | 3 | 0 | 1.5 | |
| 57 | BSTS302P | Advanced Competitive Coding - II | Soft Skill | 1.0 | 0 | 0 | 3 | 0 | 1.5 | |
| 58 | CFOC102M | Introduction to Cognitive Psychology | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 | |
| 59 | CFOC105M | Emotional Intelligence | Online Course | 1.0 | 0 | 0 | 0 | 0 | 2.0 | |
| 60 | CFOC109M | Design Thinking - A Primer | Online Course | 1.0 | 0 | 0 | 0 | 0 | 1.0 | |
| 61 | CFOC119M | Training of Trainers | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 | |
| 62 | CFOC122M | Educational Leadership | Online Course | 2.0 | 0 | 0 | 0 | 0 | 3.0 | |
| 63 | CFOC130M | Human Resource Development | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 | |
| 64 | CFOC134M | Innovation, Business Models and Entrepreneurship | Online Course | 1.0 | 0 | 0 | 0 | 0 | 2.0 | |
| 65 | CFOC160M | Python for Data Science | Online Course | 1.0 | 0 | 0 | 0 | 0 | 1.0 | |
| 66 | CFOC187M | Blockchain Architecture Design and use Cases | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 | |
| 67 | CFOC188M | Ethical Hacking | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 | |
| 68 | CFOC191M | Forests and their Management | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 | |
| 69 | CFOC221M | Cloud computing | Online Course | 1.0 | 0 | 0 | 0 | 0 | 2.0 | |
| 70 | CFOC229M | Data Analytics with Python | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 | |
| 71 | CFOC235M | Rocket Propulsion | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 | |
| 72 | CFOC248M | Environmental Geomechanics | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 | |
| 73 | CFOC253M | Plastic Waste Management | Online Course | 1.0 | 0 | 0 | 0 | 0 | 2.0 | |
| 74 | CFOC268M | Environmental Quality Monitoring and Analysis | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 | |
| 75 | CFOC289M | Introduction to Database Systems | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 | |
| 76 | CFOC293M | Data Base Management System | Online Course | 1.0 | 0 | 0 | 0 | 0 | 2.0 | |
| 77 | CFOC294M | Introduction to Algorithms and Analysis | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 | |
| 78 | CFOC398M | English Language for Competitive Exams | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 | |
| 79 | CFOC404M | Patent Law for Engineers and Scientists | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 | |
| 80 | CFOC406M | Human Behaviour | Online Course | 1.0 | 0 | 0 | 0 | 0 | 2.0 | |
| 81 | CFOC409M | Literature, Culture and Media | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 | |

| Open Elective | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 82 | CFOC412M | Introduction to Political Ideologies : Contexts, Ideas and Practices | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 |
| 83 | CFOC469M | Financial Mathematics | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 |
| 84 | CFOC482M | Integrated Marketing Management | Online Course | 1.0 | 0 | 0 | 0 | 0 | 2.0 |
| 85 | CFOC486M | Managerial Skills for Interpersonal Dynamics | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 |
| 86 | CFOC502M | Modelling and Analytics for Supply Chain Management | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 |
| 87 | CFOC504M | Financial Management For Managers | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 |
| 88 | CFOC506M | Behavioral and Personal Finance | Online Course | 1.0 | 0 | 0 | 0 | 0 | 2.0 |
| 89 | CFOC532M | Introduction to Atmospheric and Space Sciences | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 |
| 90 | CFOC575M | Wildlife Ecology | Online Course | 1.0 | 0 | 0 | 0 | 0 | 3.0 |
| 91 | CFOC641M | Aircraft Design | 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 | BENG101N | Effective English Communication | Lab Only | 1.0 | 0 | 0 | 4 | 0 | 2.0 |
| 2 | 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 |

| 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** |

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

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|---|---|---|---|
| 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<br>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.<br>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** |
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| | | |
| | **Total Lecture hours:** | **45 hours** |

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|---|---|
| **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. |

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| 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.

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|---|---|---|---|---|
| **Module:8** | **Contemporary Issues** | | | **2 hours** |
| | | | | |
| | **Total Lecture hours:** | | | **60 hours** |
| **Text Book(s)** | | | | |
| 1. | Charles K. Alexander, Matthew N. O. Sadiku, "Fundamentals of Electric Circuits," 2020, Seventh Edition, McGraw Hill Higher Education. | | | |
| **Reference Books** | | | | |
| 1. | W.H.Hayt, J.E.Kemmerly & S.M.Durbin, "Engineering Circuit Analysis", 2019, Ninth Edition, McGraw Hill Higher Education. | | | |
| 2. | Allan R. Hambley, "Electrical Engineering – Principles & applications", 2016, Sixth Edition, Pearson Education, Noida, India. | | | |
| **Mode of Evaluation:** Internal Assessment (CAT, Quizzes, Digital Assignments) & Final Assessment Test (FAT) | | | | |
| Recommended by Board of Studies | 09-11-2021 | | | |
| Approved by Academic Council | No. 64 | Date | 16-12-2021 | |

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

**Course Objectives**

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

**Course Outcome**

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

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

| Module:1 | Digital Logic | 8 hours |
|---|---|---|

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

| Module:2 | Verilog HDL | 5 hours |
|---|---|---|

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

| Module:3 | Design of Combinational Logic Circuits | 8 hours |
|---|---|---|

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

| Module:4 | Design of data path circuits | 6 hours |
|---|---|---|

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

| Module:5 | Design of Sequential Logic Circuits | 8 hours |
|---|---|---|

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

| Module:6 | Design of FSM | 4 hours |
|---|---|---|

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

| Module:7 | Programmable Logic Devices | 4 hours |
|---|---|---|

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

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

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|---|---|---|---|
| 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 |
|---|---|---|

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|---|---|---|---|
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| | | **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:<br>General purpose input/ output, timers, serial communication, LCD, keypad and ADC. | **10 hours** |
| 4 | Hardware implementation of peripheral interfacing:<br>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

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|---|---|---|---|
| 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.<br>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

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|---|---|---|---|
| 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

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|---|---|---|
| **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.

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|---|---|---|
| **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** |

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|---|---|
| **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. |

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|---|---|---|---|
| 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 ($C^2$MOS) 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 |
|---|---|---|

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|---|---|---|---|---|
| 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).<br>• 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.<br>• Estimation of Power, Delay, Noise Margin.<br>• Impact of load on performance metrics. | **4 hours** |
| 3 | Analysis of CMOS inverter for given specification.<br>• 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<br>• 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** |

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|---|---|---|---|
| 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.

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|---|---|---|
| **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** |

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| 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** |
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| | | |
| | **Total Lecture hours:** | **45 hours** |

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|---|---|
| **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

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|---|---|---|---|
| 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** |

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| 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.

| | | |
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| **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** |

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|---|---|
| **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

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|---|---|---|---|
| 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** |

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|---|---|---|---|
| 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 |
|---|---|---|---|---|---|
| **BECE317L** | **Wireless and Mobile Communications** | **3** | **0** | **0** | **3** |
| **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** | **9 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** | **6 hours** |
|---|---|---|

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

| **Module:3** | **Wireless Systems and Standards** | **5 hours** |
|---|---|---|

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

| **Module:4** | **OFDM Technology** | **5 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** | **6 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** | **7 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** | **5 hours** |
|---|---|---|

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

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|---|---|---|---|---|
| intelligent surfaces. | | | | |
| | | | | |
| **Module:8** | **Contemporary Issues** | | | **2 hours** |
| | | | | |
| | | | **Total Lecture hours:** | **45hours** |
| **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 | 28-07-2022 | | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 | |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| **BECE317P** | **Wireless and Mobile Communications Lab** | **0** | **0** | **2** | **1** |
| **Pre-requisite** | **BECE306L, BECE306P** | **Syllabus version** | | | |
| | | **1.0** | | | |

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| **Course Objectives** |
| 1. To analyse the fundamentals of multipath fading and propagation models.<br>2. To understand the principles of multicarrier modulation.<br>3. To demonstrate the diversity techniques and MIMO Technology. |
| |
| **Course Outcome** |
| Students will be able to<br>1. Examine and estimate wireless channel using path loss models.<br>2. Demonstrate the principles of multicarrier modulation.<br>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.<br>(i)Selective Mapping (SLM) technique<br>(ii) Partial Transmit (PTM) Technique.<br>(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 | 28-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| BECE318L | Optical Fiber Communications | 3 | 0 | 0 | 3 |
| 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 | 6 hours |
|---|---|---|

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

| Module:2 | Signal Degradation | 7 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 | 6 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 | 7 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 | 6 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 | 7 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 | 4 hours |
|---|---|---|

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

| Module:8 | Contemporary Issues | 2 hours |
|---|---|---|

| | | | |
|---|---|---|---|
| | | **Total Lecture hours:** | **45 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 | | | |
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|---|---|---|---|
| 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 |
|---|---|---|---|---|---|
| **BECE318P** | **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

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|---|---|---|---|
| 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 |
|---|---|---|---|---|---|
| **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.

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| **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** |

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|---|---|
| **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 | |

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| 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

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

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

**Course Objectives**

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

**Course Outcome**

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

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

| **Module:1** | **Implementing Data Structures** | **5 hours** |
|---|---|---|
| Linked list, Stack, Queues, Trees, Maps, Hash Tables. | | |
| **Module:2** | **Algorithm Analysis** | **3 hours** |
| Analysis Algorithms - Asymptotic notations – Recurrences -Substitution - Recursion-tree – The master method | | |
| **Module:3** | **Algorithms with Numbers** | **3 hours** |
| Sorting and Searching- Insertion sort, Binary Search, Divide and Conquer algorithms-Merge sort, Quick Sort. | | |
| **Module:4** | **Algorithms on Strings** | **4 hours** |
| Pattern Matching- KMP, Rabin-karp algorithm, Huffman Encoding. | | |
| **Module:5** | **Graph Algorithms** | **5 hours** |
| Decomposition of graphs, Paths in graphs: BFS & DFS, Minimum Spaiining Algorithms: Prim's & Kruskals's - Single-Source (Dijktra's) & All-pairs (Floyd & Warshal's). | | |
| **Module:6** | **Algorithms for Optimization** | **5 hours** |
| Brute force, Dynamic programming, Greedy algorithms: Fractional Knapsack & Linear programming. | | |
| **Module:7** | **Search Heuristics** | **3 hours** |
| Introduction to NP Completeness, Search Heuristics, Intelligent exhaustive search, Local search heuristics. | | |
| **Module:8** | **Contemporary issues** | **2 hours** |
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| | **Total Lecture hours:** | **30 hours** |

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

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

**Course Objectives**

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

**Course Outcome**

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

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

| **Module:1** | **Implementing Data Structures** | **5 hours** |
|---|---|---|

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

| **Module:2** | **Algorithm Analysis** | **3 hours** |
|---|---|---|

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

| **Module:3** | **Algorithms with Numbers** | **3 hours** |
|---|---|---|

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

| **Module:4** | **Algorithms on Strings** | **4 hours** |
|---|---|---|

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

| **Module:5** | **Graph Algorithms** | **5 hours** |
|---|---|---|

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

| **Module:6** | **Algorithms for Optimization** | **5 hours** |
|---|---|---|

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

| **Module:7** | **Search Heuristics** | **3 hours** |
|---|---|---|

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

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

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|---|---|---|
| | **Total Lecture hours:** | **30 hours** |

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| **Text Book(s)** | | |
| 1. | Introduction to Algorithms, Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, MIT Press, Fourth edition ,2022 | |
| 2. | Mark A. Weiss, Data Structures & Algorithm Analysis in C++, 4th Edition, 2013, Pearson Education. | |
| **Reference Books** | | |
| 1. | Michael T Goodrich, Roberto Tamassia & Michael H Goldwasser, Data Structures and Algorithms in Java, Wiley 2014. | |
| 2. | Kent. D. Lee, Steve Hubbard, Data Structures and Algorithms with Python, Springer, 2015. | |
| Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test | | |
| **Indicative Experiments** | | |
| 1. | Implementing Linked list - Stacks & Queues, Trees, Maps & Hash Tables by demonstrating applications for each. | **12 hours** |
| 2. | Performance evaluation of Divide and Conquer Algorithms | **4 hours** |
| 3. | Text Processing - Compression & Encryption | **4 hours** |
| 4. | Implementing Graph Algorithms | **3 hours** |
| 5. | Implementation of Algorithms: Dynamic Programming, Greedy & Linear Programming | **3 hours** |
| 6. | Search Algorithms | **4 hours** |
| | **Total Laboratory Hours** | **30 hours** |
| Mode of Assessment: Continuous Assessment and Final Assessment Test | | |

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

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

**Course Objectives:**

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

**Course Outcomes:**

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

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

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

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

| Module:2 | Functions and Pointers | 4 hours |
|---|---|---|

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

| Module:3 | Structures and Unions | 3 hours |
|---|---|---|

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

| Module:4 | Overview of Object-Oriented Programming | 6 hours |
|---|---|---|

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

| Module:5 | Inheritance and Polymorphism | 6 hours |
|---|---|---|

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

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

**Text Book**

| | |
|---|---|
| 1 | Herbert Schildt, C: The Complete Reference, 2017, 4th Edition, McGraw Hill Education. |
| 2 | Herbert Schildt, C++: The Complete Reference, 2017, 4th Edition, McGraw Hill Education. |

**Reference Books**

| | |
|---|---|
| 1 | Yashavant Kanetkar, Let Us C: 2020, 17th Edition, BPB Publications, 2020. |
| 2 | Stanley Lippman and Josee Lajoie, C++ Primer, 2012, 5th Edition, Addison-Wesley publishers |
| 3 | Byron S Gottfried, Programming with C, 2018, 2018, 4th Edition, Schaum's outline series. |

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

**Indicative Experiments**

| | |
|---|---|
| 1. | Programs using basic control structures, branching and looping |
| 2. | Experiment the use of 1-D, 2-D arrays and strings and Functions |
| 3. | Demonstrate the application of pointers |
| 4. | Experiment structures and unions |
| 5. | Programs on basic Object-Oriented Programming constructs. |
| 6. | Demonstrate various categories of inheritance |
| 7. | Program to apply kinds of polymorphism. |
| 8. | Develop generic templates and Standard Template Libraries. |
| 9. | Demonstrate the use of Exception handling. |
| 10. | Demonstrate the working of file handling. |
| **Total Hours** | **60 hours** |

Mode of Assessment: Continuous Assessment and Final Assessment Test

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

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

**Course Objectives:**

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

**Course Outcomes:**

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

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

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

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

| Module:2 | Functions and Pointers | 4 hours |
|---|---|---|

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

| Module:3 | Structures and Unions | 3 hours |
|---|---|---|

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

| Module:4 | Overview of Object-Oriented Programming | 6 hours |
|---|---|---|

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

| Module:5 | Inheritance and Polymorphism | 6 hours |
|---|---|---|

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

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

**Text Book**

| | |
|---|---|
| 1 | Herbert Schildt, C: The Complete Reference, 2017, 4th Edition, McGraw Hill Education. |
| 2 | Herbert Schildt, C++: The Complete Reference, 2017, 4th Edition, McGraw Hill Education. |

**Reference Books**

| | |
|---|---|
| 1 | Yashavant Kanetkar, Let Us C: 2020, 17th Edition, BPB Publications, 2020. |
| 2 | Stanley Lippman and Josee Lajoie, C++ Primer, 2012, 5th Edition, Addison-Wesley publishers |
| 3 | Byron S Gottfried, Programming with C, 2018, 2018, 4th Edition, Schaum's outline series. |

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

**Indicative Experiments**

| | |
|---|---|
| 1. | Programs using basic control structures, branching and looping |
| 2. | Experiment the use of 1-D, 2-D arrays and strings and Functions |
| 3. | Demonstrate the application of pointers |
| 4. | Experiment structures and unions |
| 5. | Programs on basic Object-Oriented Programming constructs. |
| 6. | Demonstrate various categories of inheritance |
| 7. | Program to apply kinds of polymorphism. |
| 8. | Develop generic templates and Standard Template Libraries. |
| 9. | Demonstrate the use of Exception handling. |
| 10. | Demonstrate the working of file handling. |
| **Total Hours** | **60 hours** |

Mode of Assessment: Continuous Assessment and Final Assessment Test

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

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

**Course Objectives**

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

**Course Outcome**

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

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

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

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

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

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

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

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

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

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

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

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

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

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

| | | |
|---|---|---|
| **Module:7** | **Deep Learning** | **7 hours** |

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

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

| | | |
|---|---|---|
| | **Total Lecture hours:** | **45 hours** |

**Text Book(s)**

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

**Reference Books**

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

| | |
|---|---|
| | Applications, 2020, 2nd Edition, PHI Learning Pvt. Ltd., India. |
| 2. | Alpaydin ethem, Introduction to Machine Learning, 2019, 3rd edition, PHI Learning Pvt. Ltd., India. |

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

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

**Course Objectives**

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

**Course Outcomes**

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

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

| Module:1 | Orbital Mechanics | 6 hours |
|---|---|---|

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

| Module:2 | Orbital Launchers | 3 hours |
|---|---|---|

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

| Module:3 | Elements of Communication Satellite Design | 5 hours |
|---|---|---|

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

| Module:4 | Digital Transmission Basics | 4 hours |
|---|---|---|

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

| Module:5 | Satellite Link Design | 9 hours |
|---|---|---|

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

| Module:6 | VSAT and NGSO System | 7 hours |
|---|---|---|

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

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

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|---|---|---|---|---|
| DBS Satellite Systems: DVB-S2X Standards -System Design for High-Throughput Applications , Antenna Considerations, Modulation Scheme Considerations, Error Coding Considerations, Remote Sensing Application, Navigation Satellite Systems GPS-Position Calculations and Accuracy, Navigation Messages, Receiver Design,- IRNSS | | | | |
| **Module:8** | **Contemporary Issues** | | | **2 hours** |
| | | | | |
| **Lecture hours:** | | | **Total** | **45 hours** |
| **Text Book(s)** | | | | |
| 1. | Pratt, C.W. Boastian and Jeremy Allnutt "Satellite Communication", 2018, 2nd edition, John Wiley and Sons, Bangalore, India. | | | |
| **Reference Books** | | | | |
| 1. | D.Roddy, "Satellite Communications", 2011, 4th edition (sixth reprint), Tata McGraw Hill, New York. | | | |
| 2. | Anil K. Maini, Varsha Agrawal, "Satellite Communications", 2018, Wiley India Pvt. Ltd, New Delhi, India | | | |
| 3 | G. Maral, M. Bousquet, Z. Sun, "Satellite Communications Systems: Systems, Techniques and Technology", 2020 (6th Edition), John Willy and sons, New York. | | | |
| 4 | Teresa M. Braun ,"Satellite Communications Payload and System", 2021, 2nd edition, John Wiley and Sons, USA | | | |
| Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test | | | | |
| Recommended by Board of Studies | 28-02-2023 | | | |
| Approved by Academic Council | No. 69 | Date | 16-03-2023 | |

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

**Course Objectives**

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

**Course Outcomes**

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

| Module:1 | Principles of Radar | 6 hours |
|---|---|---|

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

| Module:2 | Radar Parameters | 6 hours |
|---|---|---|

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

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

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

| Module:4 | Signal & Data Processing | 6 hours |
|---|---|---|

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

| Module:5 | Radar Antennas | 8 hours |
|---|---|---|

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

| Module:6 | Types of Radars | 6 hours |
|---|---|---|

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

| Module:7 | Stealth Technology | 3 hours |
|---|---|---|

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

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

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

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

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

**Course Objectives**

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

**Course Outcomes**

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

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

| Module:1 | Robotics and Automation | 5 hours |
|---|---|---|

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

| Module:2 | Drives for Robotics | 5 hours |
|---|---|---|

Drives: Electric, hydraulic and pneumatic drives.

| Module:3 | Sensors for Robots | 7 hours |
|---|---|---|

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

| Module:4 | Robot Kinematics and Dynamics | 10 hours |
|---|---|---|

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

| Module:5 | Path Planning | 5 hours |
|---|---|---|

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

| Module:6 | Programming of Robots | 5 hours |
|---|---|---|

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

| Module:7 | Application of Robots | 6 hours |
|---|---|---|

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|---|---|---|
| Industrial robots used for welding, painting and assembly, remote controlled robots, robots for nuclear, thermal and chemical plants, industrial automation, typical examples of automated Industries, Humanoid robots, medical robots, under water robots, drones. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| | | |
| | **Total Lecture hours:** | **45 hours** |
| **Text Book(s)** | | |
| 1. | Kevin M. Lynch, Frank C. Park, "Modern Robotics- Mechanics, Planning, and Control", 2017, Cambridge University Press. | |
| **Reference Books** | | |
| 1. | R. K. Mittal, I. J. Nagrath, "Robotics and Control", 2017, McGraw Hill Education, India, | |
| 2. | Ramkumar Gandhinathan, Lentin Joseph, "ROS Robotics Projects-Build and Control Robots Powered by the Robot Operating System, Machine Learning, and Virtual Reality", 2019, Packt Publishing. | |
| 3. | Hutchinson, S., Spong, M. W., Vidyasagar, M. "Robot Modeling and Control", 2020, Wiley publications, United Kingdom. | |
| 4. | Pawlak, A. M. Sensors and Actuators in Mechatronics: Design and Applications, 2017, CRC Press, United Kingdom. | |
| 5. | Lentin Joseph, "Robot Operating System (ROS) for Absolute Beginners - Robotics Programming Made Easy, 2018, Apress. | |
| | | |
| Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test | | |

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

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

**Course Objectives**

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

**Course Outcomes**

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

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

| **Module:1** | **Information Measures** | **7 hours** |
|---|---|---|

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

| **Module:2** | **Channel Models and Capacity** | **6 hours** |
|---|---|---|

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

| **Module:3** | **Probability based Source Coding** | **6 hours** |
|---|---|---|

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

| **Module:4** | **Non Probability based Source Coding** | **5 hours** |
|---|---|---|

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

| **Module:5** | **Audio and Video Coding** | **5 hours** |
|---|---|---|

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

| **Module:6** | **Channel Coding** | **9 hours** |
|---|---|---|

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

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

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

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

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

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

**Course Objectives**

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

**Course Outcomes**

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

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

| Module 1 | EMI/EMC Concepts | 4 Hours |
|---|---|---|

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

| Module 2 | EMI Coupling Principles | 4 Hours |
|---|---|---|

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

| Module 3 | EMI Control Techniques -I | 8 Hours |
|---|---|---|

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

| Module 4 | EMI Control Techniques -II | 8 Hours |
|---|---|---|

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

| Module 5 | EMC Design of PCBs | 8 Hours |
|---|---|---|

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

| Module 6 | EMI Measurements | 5 Hours |
|---|---|---|

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

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

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

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

**Course Objectives**

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

**Course Outcomes**

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

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

| Module:1 | Optical system components | 6 hours |
|---|---|---|

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

| Module:2 | Optical digital networks | 6 hours |
|---|---|---|

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

| Module:3 | Wavelength routing networks | 6 hours |
|---|---|---|

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

| Module:4 | Packet switching and access networks | 6 hours |
|---|---|---|

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

| Module:5 | Optical transport network and network synchronization | 6 hours |
|---|---|---|

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

| Module:6 | Network performance | 8 hours |
|---|---|---|

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

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

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

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

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

**Course Objectives**

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

**Course Outcomes**

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

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

| Module:1 | Image sampling and transformations | 7 hours |
|---|---|---|
| Introduction, Fundamental steps in DIP – Elements of visual perception -Image sensing and Acquisition – Image Sampling and Quantization – Imaging geometry, discrete image mathematical characterization- Basic relationship between pixels. Basic Gray level Transformations – Histogram Processing – Smoothing spatial filters- Sharpening spatial filters. | | |
| **Module:2** | **Image Transforms** | **7 hours** |
| Two-dimensional Fourier Transform- Properties – Fast Fourier Transform – Inverse FFT- Discrete cosine transform and KL transform-Discrete Short time Fourier Transform. Introduction to Multiresolution analysis - Discrete Wavelet Transform-the Haar wavelet family | | |
| **Module:3** | **Image Enhancement in Frequency domain** | **6 hours** |
| Smoothing frequency domain filters- Sharpening frequency domain filters- Homomorphic filtering - Restoration filters: Bandpass – Band reject - Notch filter | | |
| **Module:4** | **Color Image Processing** | **5 hours** |
| Color models: RGB- HSI- CMYK -Pseudo color image processing- Color transformations – Smoothening and Sharpening | | |
| **Module:5** | **Image Compression** | **6 hours** |
| Overview of Image Compression Techniques- Entropy Encoding- Huffman – Arithmetic- LZW - JPEG and MPEG standards | | |

<table>
<tr><td>Module:6</td><td colspan="2">Image Segmentation</td><td>7 hours</td></tr>
<tr><td colspan="4">Detection of discontinuities – Edge linking and boundary detection- Thresholding - Edge based segmentation - Region based segmentation- Matching- Morphological segmentation- Watershed algorithm</td></tr>
<tr><td>Module:7</td><td colspan="2">Representation and Description</td><td>5 hours</td></tr>
<tr><td colspan="4">Boundary descriptors - Region descriptors - Texture descriptors - Use of Principal Components for Description.</td></tr>
<tr><td>Module:8</td><td colspan="2">Contemporary Issues</td><td>2 hours</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4"></td></tr>
<tr><td></td><td colspan="2">Total Lecture hours:</td><td>45 hours</td></tr>
<tr><td colspan="4">Text Book(s)</td></tr>
<tr><td>1.</td><td colspan="3">Rafael C.Gonzalez & Richard E.Woods, “Digital Image Processing”, 2017, 4th edition, Pearson Education, USA</td></tr>
<tr><td colspan="4">Reference Books</td></tr>
<tr><td>1.</td><td colspan="3">Anil K.Jain, “Fundamentals of Digital Image Processing”, 2015, 1st edition, Pearson India, India</td></tr>
<tr><td>2.</td><td colspan="3">Mark Nixon & Alberto Aguado, “Feature Extraction, and Image Processing”, 2012, 3rd edition, Elsevier’s Science & Technology Publications, Woborn MA, Great Britain.</td></tr>
<tr><td>3.</td><td colspan="3">Scott E Umbaugh, “Digital Image Processing and Analysis: Human and Computer Vision Applications with CVIP tools”, 2011, 2nd edition, CRC press, Boca Raton, FL, USA.</td></tr>
<tr><td colspan="4">Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test</td></tr>
<tr><td colspan="3">Indicative Experiments</td><td></td></tr>
<tr><td>1</td><td colspan="2">(a) Perform point to point operation on the given image and compute the following and interpret changes in image<br>i. Image Negative<br>ii. Power law transformation<br>iii. Log transformation<br>(b) Perform contrast stretching for the given poor contrast image.<br>(c) Perform histogram equalization for the given image and analyze the enhanced quality of the image.</td><td>3 hours</td></tr>
<tr><td>2</td><td colspan="2">a) Read the input Image and perform Interpolation and Decimation. Show the effect of image shrinking and zooming.<br>b) Read the input image and show the effect of gray level slicing for different levels.<br>c) Perform Bitplane slicing for given image and comment on the number of visually significant bit planes in each image.</td><td>3 hours</td></tr>
<tr><td>3</td><td colspan="2">Implement the following spatial domain filtering techniques for an image<br>a) Low Pass Filtering<br>b) High Pass Filtering<br>c) Order Statistics (Median) Filtering</td><td>3 hours</td></tr>
</table>

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|---|---|---|
| 4 | Perform DFT for the given image and obtain its Fourier spectrum. Compute IDFT. Verify the symmetric property of DFT and compare the result with Discrete Cosine Transform (DCT). | **3 hours** |
| 5 | Removal of fine details in an image by frequency domain filtering and analysis of information loss. | **3 hours** |
| 6 | Perform image enhancement, feature extraction studies and compression using DCT. | **3 hours** |
| 7 | a) Perform image enhancement, feature extraction studies and compression using DWT.<br>b) Perform DWT of an image, analyze and further reconstruct the image using IDWT | **3 hours** |
| 8 | Segment the region of interest from a given image using region-based segmentation and watershed algorithm. | **3 hours** |
| 9 | Identifying objects in an image based on their boundaries. | **3 hours** |
| 10 | To detect moving objects in given image frames using background subtraction algorithm. | **3 hours** |
| | **Total Laboratory Hours** | **30 hours** |

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|---|---|---|---|
| Mode of assessment: Continuous assessment and FAT | | | |
| Recommended by Board of Studies | 28-02-2023 | | |
| Approved by Academic Council | No. 69 | Date | 16-03-2023 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| BECE391J | Technical Answers to Real Problems Project | 0 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. To gain an understanding of real-life issues faced by society.
2. To study appropriate technologies in order to find a solution to real life issues.
3. Students will design system components intended to solve a real-life issue.

**Course Outcomes**

1. Identify real life issue(s) faced by society.
2. Apply appropriate technologies to suggest a solution to the identified issue(s).
3. Design the related system components/processes intended to provide a solution to the identified issue(s).

**Module Content** **(Project Duration: Two Semesters)**

1. Students are expected to perform a survey and interact with society to find out the real life issues.
2. Logical steps with the application of appropriate technologies should be suggested to solve the identified issues.
3. Subsequently the student should design the related system components or processes which is intended to provide the solution to the identified real-life issues.

**General Guidelines:**

1. Identification of real-life problems
2. Field visits can be arranged by the faculty concerned
3. Maximum of 3 students can form a team (within the same/different discipline)
4. Minimum of eight hours on self-managed team activity
5. Appropriate scientific methodologies to be utilized to solve the identified issue
6. Solution should be in the form of fabrication/coding/modelling/product design/process design/relevant scientific methodology(ies)
7. Consolidated report to be submitted for assessment
8. Participation, involvement and contribution in group discussions during the contact hours will be used as the modalities for the continuous assessment of the theory component
9. Project outcome to be evaluated in terms of technical, economical, social, environmental, political and demographic feasibility
10. Contribution of each group member to be assessed

**Mode of Evaluation:** Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews

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| Recommended by Board of Studies | 12-10-2022 | | |
| Approved by Academic Council | No. 68 | Date | 19-12-2022 |

| Course Code | Course Title | | L | T | P | C |
|---|---|---|---|---|---|---|
| **BECE392J** | **Design Project** | | **0** | **0** | **0** | **3** |
| **Pre-requisite** | **NIL** | **Syllabus version** | | | | |
| | | **1.0** | | | | |

**Course Objectives**

1. Students will be able to upgrade a prototype to a design prototype.
2. Describe and demonstrate the techniques and skills necessary for the project.
3. Acquire knowledge and better understanding of design systems.

**Course Outcomes**

1. Develop new skills and demonstrate the ability to upgrade a prototype to a design prototype or working model.
2. Utilize the techniques, skills, and modern tools necessary for the project.
3. Synthesize knowledge and use insight and creativity to better understand and improve design systems.

**Module Content** **(Project Duration: One Semester)**

Students are expected to develop new skills and demonstrate the ability to develop prototypes to design prototype or working models related to an engineering product or a process.

**Mode of Evaluation:** Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews.

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| Recommended by Board of Studies | 12-10-2022 | | |
| Approved by Academic Council | No. 68 | Date | 19-12-2022 |

| Course Code | Course Title | | L | T | P | C |
|---|---|---|---|---|---|---|
| **BECE393J** | **Laboratory Project** | | **0** | **0** | **0** | **3** |
| **Pre-requisite** | **NIL** | **Syllabus version** | | | | |
| | | **1.0** | | | | |

**Course Objectives**

1. The student will be able to conduct experiments on the concepts already learnt.
2. Analyse experimental data.
3. Present the results with appropriate interpretation.

**Course Outcomes**

1. Design and conduct experiments in order to gain hands-on experience on the concepts already studied.
2. Analyse and interpret experimental data.
3. Write clear and concise technical reports and research articles

**Module Content** **(Project Duration: One Semester)**

Students are expected to perform experiments and gain hands-on experience on the theory courses they have already studied or registered in the ongoing semester. The theory course registered is not expected to have laboratory component and the student is expected to register with the same faculty who handled the theory course. This is mostly applicable to the elective courses. The nature of the laboratory experiments is depended on the course.

**Mode of Evaluation:** Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews.

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| Recommended by Board of Studies | 12-10-2022 | | |
| Approved by Academic Council | No. 68 | Date | 19-12-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| **BECE394J** | **Product Development Project** | **0** | **0** | **0** | **3** |
| **Pre-requisite** | **NIL** | **Syllabus version** | | | |
| | | **1.0** | | | |

**Course Objectives**

1. Students will be able to translate a prototype to a useful product.
2. Apply relevant codes and standards during product development.
3. The student will be able to present his results by means of clear technical reports.

**Course Outcomes**

1. Demonstrate the ability to translate the developed prototype/working model to a viable product useful to society/industry.
2. Apply the appropriate codes/regulations/standards during product development.
3. Write clear and concise technical reports and research articles

| **Module Content** | **(Project Duration: Two Semesters)** |
|---|---|

Students are expected to translate the developed prototypes / working models into a product which has application to society or industry.

**Mode of Evaluation:** Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews

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| Recommended by Board of Studies | 12-10-2022 | | |
| Approved by Academic Council | No. 68 | Date | 19-12-2022 |

| **Course Code** | **Course Title** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| **BECE396J** | **Reading Course** | **0** | **0** | **0** | **3** |
| **Pre-requisite** | **NIL** | **Syllabus version** | | | |
| | | **1.0** | | | |

**Course Objectives**

1. The student will be able to analyse and interpret published literature for information pertaining to niche areas.
2. Scrutinize technical literature and arrive at conclusions.
3. Use insight and creativity for a better understanding of the domain of interest.

**Course Outcomes**

1. Retrieve, analyse, and interpret published literature/books providing information related to niche areas/focused domains.
2. Examine technical literature, resolve ambiguity, and develop conclusions.
3. Synthesize knowledge and use insight and creativity to better understand the domain of interest.

| **Module Content** | **(Project Duration: One Semester)** |
|---|---|

This is oriented towards reading published literature or books related to niche areas or focussed domains under the guidance of a faculty.

**Mode of Evaluation:** Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews.

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| Recommended by Board of Studies | 12-10-2022 | | |
| Approved by Academic Council | No. 68 | Date | 19-12-2022 |

| **Course Code** | **Course Title** | | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|---|
| **BECE397J** | **Special Project** | | **0** | **0** | **0** | **3** |
| **Pre-requisite** | **NIL** | **Syllabus version** | | | | |
| | | **1.0** | | | | |

**Course Objectives**

1. Students will be able to identify and solve problems in a time-bound manner.
2. Describe major approaches and findings in the area of interest.
3. Present the results in a clear and concise manner.

**Course Outcomes**

1. To identify, formulate, and solve problems using appropriate information and approaches in a time-bound manner.
2. To demonstrate an understanding of major approaches, concepts, and current research findings in the area of interest.
3. Write clear and concise research articles for publication in conference proceedings/peer-reviewed journals.

**Module Content** **(Project Duration: Three Semesters)**

This is an open-ended course in which the student is expected to work on a time bound research project under the supervision of a faculty. The result may be a tangible output in terms of publication of research articles in a conference proceeding or in a peer-reviewed Scopus indexed journal.

**Mode of Evaluation:** Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – project report to be submitted, presentation and project reviews.

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| Recommended by Board of Studies | 12-10-2022 | | |
| Approved by Academic Council | No. 68 | Date | 19-12-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| BECE398J | Simulation Project | 0 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Students will be able to simulate a real system.
2. Identify the variables which affect the system.
3. Describe the performance of a real system.

**Course Outcomes**

1. Demonstrate the ability to simulate and critically analyse the working of a real system.
2. Identify and study the different variables which affect the system elaborately.
3. Evaluate the impact and performance of the real system.

**Module Content** **(Project Duration: One Semester)**

The student is expected to simulate and critically analyse the working of a real system. Role of different variables which affect the system has to be studied extensively such that the impact of each step in the process is understood, thereby the performance of each step of the engineering process is evaluated.

**Mode of Evaluation:** Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – project report to be submitted, presentation and project reviews.

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| Recommended by Board of Studies | 12-10-2022 | | |
| Approved by Academic Council | No. 68 | Date | 19-12-2022 |

| Course Code | Course Title | | L | T | P | C |
|---|---|---|---|---|---|---|
| BECE403E | Embedded Systems Design | | 3 | 0 | 2 | 4 |
| Pre-requisite | BECE204L, BECE204P | Syllabus version | | | | |
| | | 1.0 | | | | |

**Course Objectives**

1. To acquaint students with definition, characteristics, challenges and design lifecycle of Embedded Systems by imparting the fundamental knowledge of I/O interfacing, serial communication protocols, wireless technologies, design using UML models
2. To familiarize the concepts and features of Real-time operating systems, task scheduling, and inter-task communication.
3. To impart various programming tools, modeling and simulation packages to program, design, simulate and build Embedded Systems

**Course Outcomes**

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

1. Design any application, based on the given specifications by keeping in mind different design metrics.
2. Apply the skills attained to differentiate Microprocessor/Microcontroller and interface various peripherals for a particular application.
3. Demonstrate proficiency in using device drivers, firmware and debugging tools.
4. Analyze the specific perspective of the embedded application using different modelling languages
5. Compare and contrast various wired and wireless protocols
6. Explore the concepts of RTOS and apply the knowledge for developing real-time systems

| Module:1 | Embedded System Product Development | 4 hours |
|---|---|---|
| Characteristics of embedded systems, Classification of embedded systems, Embedded product development cycle, Embedded System Design Challenges, Performance and Benchmarking Tools. | | |
| **Module:2** | **Embedded Hardware Design** | **5 hours** |
| Processor classification - general purpose, customized, application specific processors, Microcontroller architectures (RISC, CISC), Embedded Memory, Strategic selection of processor and memory, Power Supply Design Considerations for Embedded Systems. | | |
| **Module:3** | **Embedded Software Development Environment** | **6 hours** |
| Cross assemblers/compilers, Linker, Runtime Library, Pre-processor Workflow, make files, Compiler Tool chains – gcc & ARM, Device Driver, Firmware, Middleware - Debugging tools: Emulators, Simulators, In-Circuit Debuggers, Logic Analyzer, Integrated Development Environment (IDE). | | |
| **Module:4** | **Modeling Embedded Systems** | **6 hours** |
| Control data flow graph, Finite state machine model, Petrinet Model, Unified model language | | |
| **Module:5** | **Programming the Peripherals of Microcontrollers** | **6 hours** |
| Programming GPIO pins, Timers / Counters, Watchdog Timer, PWM generation, ADC, DAC, LED, switches, keypad, LCD. | | |
| **Module:6** | **Emerging Communication Protocols** | **8 hours** |

| | | |
|---|---|---|
| UART, SPI, I2C, NFC, CAN, Bluetooth, Zigbee, Wi-Fi | | |
| **Module:7** | **Embedded Real –Time Operating Systems** | **8 hours** |
| Introduction to basic concepts of RTOS- Task, process & threads, Multiprocessing and Multitasking, Preemptive and non-preemptive scheduling, Schedulability Analysis, Inter process Communication, Performance Metrics of RTOS | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| | | |
| | **Total Lecture hours:** | **45 hours** |

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|---|---|
| **Text Book(s)** | |
| 1. | Raj Kamal, “Embedded systems Architecture, Programming and Design”, 2017, Third Edition, McGraw Hill Education, India. |
| **Reference Books** | |
| 1. | Marilyn Wolf, “Computers as components: Principles of Embedded Computing System Design”, 2017, Fourth Edition, Morgan Kaufmann publications (Elsevier), United States. |
| 2. | Jiacun Wang, "Real-Time Embedded Systems", 2017, First Edition, Wiley Publishers, United States. |
| Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test | |

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|---|---|---|
| **Indicative Experiments** | | |
| 1. | Experiments based on interfacing I/O devices | **4 hours** |
| 2. | Experiments based on monitoring and control using sensors and actuators | **6 hours** |
| 3. | Experiments based on wired Communications Protocols (UART, SPI, I2C, CAN) | **8 hours** |
| 4. | Experiments based wireless Communications Protocols (Wi-Fi, Bluetooth) | **6 hours** |
| 5. | Experiments based on RTOS | **6 hours** |
| | **Total Laboratory Hours** | **30 hours** |
| Mode of assessment: Continuous assessment and FAT | | |

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

| Course Code | Course Title | | L | T | P | C |
|---|---|---|---|---|---|---|
| BECE404L | Detection, Estimation and Modulation Theory | | 3 | 0 | 0 | 3 |
| Pre-requisite | BECE207L | Syllabus version | | | | |
| | | 1.0 | | | | |

**Course Objectives**

1. To familiarize the students a hypothesis testing for various signal detection models.
2. To make them understand and apply Gaussian detection scheme.
3. To make them proficient in scalar and vector parameter estimation.
4. To let them develop an expertise in Kalman filter based estimation.

**Course Outcomes**

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

1. Postulate the hypothesis testing.
2. Apply Gaussian detection in suitable signal processing applications.
3. Develop a scheme to estimate scalar and vector parameters using the classical scheme of parameter estimation.
4. Estimate the parameters of importance through Gaussian estimation method.
5. Design and implement the estimators for continuous time random processes.
6. Apply Kalman filter based estimation in suitable signal processing applications.

| Module:1 | Classical Detection Theory | 6 hours |
|---|---|---|

Introduction - Simple Binary Hypothesis Tests - Decision Criteria - Performance: Receiver Operating Characteristic - M Hypotheses - Performance Bounds and Approximations - Monte Carlo Simulation - Importance Sampling -Simulation of PF - Simulation of PM - Independent Observations - Simulation of the ROC, Examples, Iterative Importance Sampling.

| Module:2 | Gaussian Detection | 8 hours |
|---|---|---|

Real and Circular Complex Gaussian Random Vectors - General Gaussian Detection - Equal Covariance Matrices - Independent Components with Equal and Unequal Variances - Eigen decomposition - Optimum Signal Design - Interference Matrix: Estimator – Subtractor - Low-Rank Models - Equal Mean Vectors - Diagonal Covariance Matrix on H0: Equal Variance – Independent and Identically Distributed Signal Components - Independent Signal Components: Unequal Variances - Correlated Signal Components - Low-Rank Signal Model - Symmetric Hypotheses - Uncorrelated Noise - Nondiagonal Covariance Matrix on H0, H1, Signal on Both Hypotheses, M Hypotheses

| Module:3 | Classical Parameter Estimation | 6 hours |
|---|---|---|

Introduction - Scalar Parameter Estimation - Random Parameters: Bayes Estimation - Nonrandom Parameter Estimation - Bayesian Bounds - Lower Bound on the MSE - Asymptotic Behavior - Exponential Family - Nonrandom Parameters - Random Parameters - Summary of Scalar Parameter Estimation

| Module:4 | Multiple Parameter Estimation | 5 hours |
|---|---|---|

Multiple Parameter Estimation - Estimation Procedures - Random Parameters - Nonrandom Parameters - Measures of Error- Nonrandom Parameters - Random Parameters - Bounds on Estimation Error - Nonrandom Parameters - Random Parameters - Hybrid Parameters - Hybrid Parameters - Joint ML and MAP Estimation

| Module:5 | Gaussian Estimation | 7 hours |
|---|---|---|

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|---|---|---|
| Introduction - Nonrandom Parameters - General Gaussian Estimation Model - Maximum Likelihood Estimation - Crammer–Rao Bound - Fisher Linear Gaussian Model - White Noise - Low-Rank Interference - Separable Models for Mean Parameters - Covariance Matrix Parameters - White Noise - Colored Noise - Rank One Signal Matrix Plus White Noise - Rank One Signal Matrix Plus Colored Noise - Linear Gaussian Mean and Covariance Matrix Parameters - White Noise - | | |
| **Module:6** | **Estimation of Continuous-Time Random Processes** | **5 hours** |
| Optimum Linear Processors - Realizable Linear Filters: Stationary Processes, Infinite Past: Wiener Filters - Solution of Wiener–Hopf Equation - Errors in Optimum Systems - Unrealizable Filters - Closed-Form Error Expressions | | |
| **Module:7** | **Kalman Filter Based Estimation** | **6 hours** |
| Gaussian - Markov Processes: Kalman Filter - Differential Equation Representation of Linear Systems and Random Process Generation - Kalman Filter - Realizable Whitening Filter - Generalizations - Implementation Issues - Bayesian Estimation of Non-Gaussian Models - The Extended Kalman Filter - Linear AWGN Process and Observations - Linear AWGN Process, Nonlinear AWGN Observations | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| | | |
| | **Total Lecture hours:** | **45 hours** |

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| **Text Book(s)** | |
| 1. | Harry L. Van Trees, “Detection Estimation and Modulation Theory”, John Wiley, 2013. |
| **Reference Books** | |
| 1. | Bernard C. Levy, “Principles of Signal Detection and Parameter Estimation”, Springer New York, NY, ISBN 978-0-387-76542-6, 2008 |
| 2. | H. Vincent Poor, “An Introduction to Signal Detection and Estimation”, Springer New York, NY, 1994 |

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

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

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| BECE405L | Cognitive Radio Networks | 3 | 0 | 0 | 3 |
| Pre-requisite | BECE307L, BECE307P/ BECE317L, BECE317P | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. To understand the principles and importance of cognitive radio in the context of next-generation networks
2. To analyze various spectrum sensing, access and management protocols
3. To introduce the challenges and opportunities associated with cognitive radio networks

**Course Outcomes**

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

1. Solve the fundamental challenges associated with security, medium access control and network layers.
2. Analyze the performance of various spectrum access, sensing and management schemes.
3. Create the network layer suitable for CRNs.
4. Use modern tools for the implementation of spectrum access, sensing and management protocols.
5. Make a presentation on assigned topic related to this course.

| Module:1 | Introduction to Cognitive Radio | 6 hours |
|---|---|---|

Evolution of Cognitive Radio, Cognitive Radio in 4G/5G Wireless Communications, Key Applications-Interoperability, Dynamic Spectrum Access, Regulatory Issues of Cognitive Access, Cognitive radio architecture, Introduction to software defined radio (SDR)-architecture and design principles, Reconfigurable wireless communication systems

| Module:2 | Spectrum Access and Sharing | 6 hours |
|---|---|---|

Unlicensed Spectrum Sharing, Licensed Spectrum Sharing, Secondary Spectrum Access, Non-Real-Time Spectrum Access and Sharing, Real-Time Spectrum Access and Sharing- Negotiated Access, Opportunistic Access, Overlay Approach, Underlay Approach

| Module:3 | Spectrum Sensing and Management | 8 hours |
|---|---|---|

Spectrum Sensing to Detect Specific Primary System-Conventional spectrum sensing, power control, Power-scaling power control, Cooperative spectrum sensing, Spectrum sensing procedure. Spectrum Sensing for Cognitive Multi-Radio Networks-Multiple system sensing, Radio resource sensing

| Module:4 | Medium Access Control | 7 hours |
|---|---|---|

MAC for cognitive radios, Multi-channel MAC-Collision avoidance/resolution, Access negotiation, Slotted-ALOHA with Rate-Distance Adaptability, CSMA with AMC-CSMA with spatial reuse transmissions, Cross layer power-rate control scheme

| Module:5 | Network Layer Design | 6 hours |
|---|---|---|

Routing in Mobile Ad Hoc Networks-Features of routing in cognitive radio networks (CRN), Dynamic source routing in MANET, Ad-hoc on-demand distance vector (AODV), Routing in CRN-Routing of dynamic and unidirectional cognitive radio links

| | | |
|---|---|---|
| in CRN, Control of CRN-Flow control and end-to-end error control, Network tomography, Self-Organized CRNs. | | |
| **Module:6** | **Trusted Cognitive Radio Networks** | **6 hours** |
| Framework of Trust in CRN, Trusted Association and Routing, Trust with Learning-Modified Bayesian learning, Learning experiments for CRN, Security in CRN-Dilemma of CRN security, Requirements and challenges for preserving user privacy in CRNs, Implementation of CRN security. | | |
| **Module:7** | **Spectrum Management** | **4 hours** |
| Spectrum Sharing, Spectrum Pricing, Mobility Management of Heterogeneous Wireless Networks, Regulatory Issues and International Standards | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| | | |
| | | |
| | **Total Lecture hours** | **45 hours** |

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|---|---|
| **Text Book(s)** | |
| 1. | Ahmed Khattab, Dmitri Perkins, Magdy Bayoumi, Cognitive Radio Networks, Springer New York, NY, 2013. |
| **Reference Books** | |
| 1. | Setoodeh, P., & Haykin, S. (2017). Fundamentals of cognitive radio. John Wiley & Sons. |
| 2. | Alexander M. Wyglinski, Maziar Nekovee, Thomas Hou, Cognitive Radio Communications and Networks, Academic Press, Elsevier, 2010. |
| 3. | Xiao, Y., & Hu, F. (Eds.). (2019). Cognitive radio networks. CRC press. |
| 4. | Ezio Biglieri, Andrea J. Goldsmith, Larry J. Greenstein, Narayan B. Mandayam, H. Vincent Poor, “Principles of Cognitive Radio”, Cambridge, 2012 |

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

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

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| BECE406E | FPGA Based System Design | 2 | 0 | 2 | 3 |
| Pre-requisite | BECE102L, BECE102P | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Understand FPGA Architecture and technologies
2. Modeling of complex digital sub-systems
3. Implementation of complex FPGA applications in real world scenario

**Course Outcomes**

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

1. Understand architectures of programmable logic devices
2. Understand various abstraction level in Verilog HDL
3. Construct high speed arithmetic and memory circuits
4. Analyze the synthesis and timing constraints/reports
5. Design the system using soft core processors
6. Develop the FPGA based system for various applications in signal processing
7. Develop and prototype digital systems using FPGA

| Module | Title | Hours |
|---|---|---|
| **Module:1** | **Programmable Logic Devices** | **4 hours** |
| Types of Programmable Logic Devices: PLA, PAL, CPLD - FPGA Architecture – Programming Technologies-Chip I/O- Programmable Logic Blocks- Fabric and Architecture of FPGA. | | |
| **Module:2** | **HDL Fundamentals** | **3 hours** |
| Verilog Behavioral, Data Flow and Structural Modeling, Useful Modeling Techniques. | | |
| **Module:3** | **Implementation of Arithmetic system** | **5 hours** |
| Arithmetic Circuits: High Speed Adders, Carry look-ahead adder, Carry save adders, Conditional Sum adders, Sequential and Parallel Multipliers | | |
| **Module:4** | **FSM and memory modelling** | **5 hours** |
| Synchronous and Asynchronous FIFO – Single port and Dual port ROM and RAM - FSM Verilog modeling of Sequence detector - Serial adder - Vending machine. | | |
| **Module:5** | **Synthesis and Timing Analysis** | **3 hours** |
| Synthesis, Optimization of Speed: Introduction, Strategies for Timing Improvement; Optimization of Area, Optimization of power | | |
| **Module:6** | **SoC Design** | **4 hours** |
| Introduction to hardware – software codesign, Introduction to Qsys and Intel Quartus prime tool, Nios II Software Build Tools for Eclipse, Incorporate custom peripherals & instructions into an embedded system. | | |
| **Module:7** | **FPGA Applications** | **4 hours** |
| Embedded system design using FPGAs, DSP using FPGAs, Dynamic architecture using FPGAs, reconfigurable systems, application case studies. Simulation / implementation exercises of combinational, sequential and DSP kernels on Xilinx / Altera boards. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| | **Total Lecture hours:** | **30 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Michael D Ciletti, Advanced Digital Design with the Verilog HDL, Prentice Hall, Second Edition, 2017. |
| **Reference Books** | |
| 1. | Charles H Roth Jr, Lizy Kurian John and ByeongKil Lee Digital Systems Design using Verilog, Cengage Learning, First Edition, 2016. |
| 2. | Wayne Wolf, FPGA Based System Design, Prentices Hall Modern Semiconductor Design Series, 2011. |
| 3. | Ming-Bo Lin, Digital Systems Design and Practice: Using Verilog HDL and FPGAs, Create Space Independent Publishing Platform, Second Edition, 2015. |
| Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test | |

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|---|---|---|
| **Indicative Experiments** | | |
| 1. | Design of adders and Multipliers | **6 hours** |
| 2. | Design of FSM | **6 hours** |
| 3. | Design of Memory circuits | **6 hours** |
| 4. | Synthesis and Timing Analysis | **6 hours** |
| 5. | System design using Qsys | **6 hours** |
| | **Total Laboratory Hours** | **30 hours** |
| Mode of assessment: Continuous assessment and FAT | | |

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

| Course Code | Course Title | | L | T | P | C |
|---|---|---|---|---|---|---|
| **BECE407E** | **ASIC Design** | | **2** | **0** | **2** | **3** |
| **Pre-requisite** | **BECE303L, BECE303P** | **Syllabus version** | | | | |
| | ` | **1.0** | | | | |

**Course Objectives**

1. Explain the HDL coding guidelines, synthesizable HDL constructs and RTL synthesis Flow with respect to different cost functions.
2. Teach how to perform Static Timing Analysis for ASIC design.
3. Discuss the guidelines at each abstraction level in physical design
4. Provide detailed insight on importance of physical design verification

**Course Outcomes**

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

1. Design a digital system by adhering to synthesizable HDL constructs.
2. Synthesize the given design by considering various constraints and to optimize the same.
3. Understand various timing parameters and perform Static Timing Analysis for ASIC design
4. Perform physical design by adhering to guidelines.
5. Apprehend the importance of physical design verification.
6. Design ASIC based systems using industry standard tools.

| | | |
|---|---|---|
| **Module:1** | **ASIC Design Methodology & Design Flow** | **3 hours** |
| Implementation Strategies for Digital ICs: Custom IC Design- Cell-based Design Methodology - Array based implementation approaches - Traditional and Physical Compiler based ASIC Flow. | | |
| **Module:2** | **Verilog HDL Coding Style for Synthesis** | **6 hours** |
| HDL Coding style – Guidelines and Recommendation - FSM Coding Guideline and Coding Style for Synthesis. Datapath and Control Logic Design. | | |
| **Module:3** | **RTL Synthesis** | **3 hours** |
| RTL synthesis Flow – Synthesis Design Environment & Constraints – Architecture of Logic Synthesizer - Technology Library Basics– Components of Technology Library –Synthesis Optimization- Technology independent and Technology dependent synthesis- Data path Synthesis – Low Power Synthesis - Formal Verification. | | |
| **Module:4** | **Basic Timing Analysis** | **4 hours** |
| Timing Parameter Definition – Setup Timing Check- Hold Timing Check- Multicycle Paths- Half-Cycle Paths- False Paths | | |
| **Module:5** | **Advanced Timing Analysis** | **5 hours** |
| Clock skew optimization – On-Chip Variations- AOCV-Time Borrowing- Setup and Hold Violation Fixing. | | |
| **Module:6** | **Physical Design** | **5 hours** |
| Detailed steps in Physical Design Flow- Guidelines for Floor plan, Placement, CTS and routing– ECO flow – Signal Integrity Issues. | | |
| **Module:7** | **Physical Design Verification** | **3 hours** |
| Timing Sign-off, Physical Verification – Signoff DRC and LVS, ERC, IR Drop Analysis, Electro-Migration Analysis and ESD Analysis. | | |
| **Module:8** | **Contemporary Issues** | **1 hours** |
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|---|---|---|---|
| | **Total Lecture hours:** | | **30 hours** |
| **Text Book(s)** | | | |
| 1. | Vaibbhav Taraate, ASIC Design and Synthesis RTL Design Using Verilog, Springer, First Edition, 2021, Singapore. | | |
| **Reference Books** | | | |
| 1. | Khosrow Golshan, PHYSICAL DESIGN ESSENTIALS An ASIC Design Implementation Perspective, First Edition, 2010. | | |
| 2. | Michael John Sebastian Smith, Application-Specific Integrated Circuits, First Edition, 2002. | | |
| 3. | J. Bhasker and Rakesh Chadha, Static Timing Analysis for Nanometer Designs, Springer, First Edition, 2010, USA. | | |
| Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test | | | |
| **Indicative Experiments** | | | |
| 1. | Design of Digital Architecture for given specification | | **6 hours** |
| 2. | Logical Synthesis of Digital Architecture | | **6 hours** |
| 3. | Netlist Optimization and Formal Verification | | **6 hours** |
| 4. | Physical Synthesis of Digital Architecture | | **6 hours** |
| 5. | Physical Verification of digital architecture | | **6 hours** |
| | **Total Laboratory Hours** | | **30 hours** |
| Mode of assessment: Continuous assessment and FAT | | | |
| Recommended by Board of Studies | 28-02-2023 | | |
| Approved by Academic Council | No. 69 | Date | 16-03-2023 |

| Course Code | Course Title | | L | T | P | C |
|---|---|---|---|---|---|---|
| BECE408L | Microwave Integrated Circuits | | 3 | 0 | 0 | 3 |
| Pre-requisite | BECE305L, BECE305P | Syllabus version | | | | |
| | | 1.0 | | | | |

**Course Objectives**

1. To have the essential knowledge of various planar microstrip circuits
2. To design and analyse various types of microwave planar circuits
3. To acquaint the fabrication techniques and tolerances for MIC circuits

**Course Outcomes**

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

1. Comprehend the importance of various microstrip lines and the losses due to various microstrip discontinuities
2. Design the lumped elements for microwave circuits
3. Analyze various microstrip resonators
4. Design and analyze band pass filters
5. Design the various microwave amplifiers, oscillators and mixers
6. Evaluate the performance of various fabrication techniques for planar circuits

| Module:1 | Planar transmission lines | 6 hours |
|---|---|---|

Introduction, types of MICs and their technology; Microstrip lines, strip lines, slotted lines, co-planar waveguides, coupled lines and SIW. Losses in microstrip transmission lines.

| Module:2 | Passive elements for MICs and discontinuities | 8 hours |
|---|---|---|

Lumped microstrip components: Design of microstrip and chip inductors, capacitors, resistors, Quasi lumped microstrip elements: Open and short circuited stubs (quarter wavelength, half wavelength). Interdigital capacitors, Approximate analysis. Discontinuities: Corners, symmetrical step, T-junction and series gaps

| Module:3 | Microstrip Resonators | 6 hours |
|---|---|---|

Analysis and Design of Quarter & Half wave length resonators, Ring resonators, Patch resonators and Slot resonators.

| Module:4 | Microwave Filter Design | 7 hours |
|---|---|---|

Introduction, Band pass filter: Insertion loss method, Conversion from low pass to band pass, Design of band pass filter using lumped elements, distributed elements, impedance inverters and coupled line filters.

| Module:5 | Microwave Amplifiers | 6 hours |
|---|---|---|

Single stage amplifier design for maximum and specific gain, Noise figure, Design of low noise amplifiers, Gain compression, Intermodulation distortion, third order intercept point, dynamic range.

| Module:6 | Microwave Oscillators and Mixers | 5 hours |
|---|---|---|

Conditions for oscillations, one port oscillator, two port oscillator (Transistor oscillators), Characteristics of mixer, Single ended diode mixer, Single ended FET mixer and Image reject mixer.

| Module:7 | MIC and MMIC Fabrication Technologies | 5 hours |
|---|---|---|

Hybrid MICs, Configuration, Dielectric substances, thick and thin film technology, LTCC, HTCC, Printed Circuit Board (PCB) Technology, Fabrication process of MMIC

| Module:8 | Contemporary Issues | 2 hours |
|---|---|---|

| | | | |
|---|---|---|---|
| | | **Total Lecture hours:** | **45 hours** |
| **Text Book(s)** | | | |
| 1. | TC Edwards,MB Steer ,Foundations for Microstrip circuit design, 4e, 2016, John Wiley, UK | | |
| **Reference Books** | | | |
| 1.<br>2.<br>3. | Ali A Behagi, RF and Microwave Circuit Design: A Design Approach using ADS, 2017, 1e, Techno Search, India.<br>D. M. Pozar, Microwave engineering, 2020, 4e, John Wiley, India.<br>G Gonzalez, Microwave transistor amplifiers, 1997, 2e, PHI Inc., NJ | | |
| Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test | | | |

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

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| BECE409E | Sensors Technology | 2 | 0 | 2 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. To attain a broad familiarity with the principle of sensing and different sensors for real world applications
2. Study the various sensor technologies for the measurement of physical quantities and develop suitable signal conditioning circuits.
3. Identify most suitable sensors for each measurement application and get acquainted with fabrication and interfacing process

**Course Outcomes**

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

1. Understand the sensors, sensor materials and sensor technologies.
2. Utilize various RLC and self-generating sensors for measuring physical quantities
3. Design appropriate signal conditioning and compensating circuits for RLC sensors
4. Fabricate various sensors using different fabrication techniques
5. Explore advanced sensing mechanisms.
6. Explore smart sensors and IOT for various sensor applications
7. Integrate the various sensors, work with them and interpret the data obtained from various applications.

| Module:1 | Sensing Mechanism | 4 hours |
|---|---|---|

Principles of Sensing: Resistive, Capacitive, Magnetic, Inductive, Piezoelectric, Piezo-resistance, Pyro-electric, Hall effect, RF sensing. Sensor materials and material properties. Sensor Technologies: Micro Technology, Micro-Electro-Mechanical Systems Technology, Nanotechnology. Example of Smart Sensors in Nature (Vision, Hearing, Touch, and Smell).

| Module:2 | RLC and Self Generating Sensors | 4 hours |
|---|---|---|

Resistive Sensors – Strain Gauges, Resistance Temperature Detectors, Thermistors, Light dependent resistors, Self and Mutual Inductive Transducers, LVDT, Capacitive Transducers, Variable Distance, Variable Area, Variable Dielectric Type Capacitive Sensors. Self-Generating Sensors – Thermoelectric Sensors, Piezoelectric Sensors, Pyroelectric sensors, Photovoltaic sensors, Electrochemical Sensors.

| Module:3 | Sensor Signal Conditioning | 4 hours |
|---|---|---|

DC Bridges for Resistance Measurements-Wheatstone Bridge, Kelvin Bridge. AC Bridges for Capacitance and Inductance Measurements-AC Bridge, Schering Bridge. Sensor Compensation Circuits-Temperature, Non-linearity and Offset Compensation.

| Module:4 | Sensor Fabrication | 4 hours |
|---|---|---|

Thick and Thin Film Sensor Fabrication – Screen Printing Technology, PVD, CVD, Fabrication of MEMS and NEMS Sensors – Lithography, Micromachining Techniques

| Module:5 | Advanced Sensors | 4 hours |
|---|---|---|

| | | |
|---|---|---|
| Position Encoders, Resonant Sensors, Sensors Based on Semiconductor Junctions, Fiber-Optic Sensors, Ultrasonic-Based Sensors, Biosensors, Superconducting Quantum Interference Devices (SQUIDs). | | |
| **Module:6** | **Smart Sensors** | **4 hours** |
| Smart Transducers: Smart Sensors, Components of Smart Sensors, General Architecture of Smart Sensors, Evolution of Smart Sensors, Advantages, Application area of Smart Sensors. | | |
| **Module:7** | **Sensors for IoT** | **4 hours** |
| Sensor-Cloud; Fog Computing, Smart Cities and Smart Homes, Connected Vehicles, Smart Grid, Industrial IoT, Case Study: Agriculture, Healthcare, Activity Monitoring | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| | | |
| | **Total Lecture hours:** | **30 hours** |

**Text Book(s)**

1. Winncy Y. Du, "Resistive, Capacitive, Inductive, and Magnetic Sensor Technologies", 2019, 1st Edition, CRC press, London.
2. B. C. Nakra and K. K. Chaudhary, "Instrumentation, Measurement and Analysis", 2016, 4th Edition, McGraw Hill Education India Private Limited.

**Reference Books**

1. A.K. Sawhney, "A Course in Electronic Measurements and Instrumentation", 2015, Dhanpat Rai & Co. (P) Limited.
2. Ramón Pallás-Areny and John G. Webster, "Sensors and Signal Conditioning" 2012, 2nd Edition, John Wiley and Sons, Inc.
3. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press, 2017.
4. Nihtianov, Stoyan, and Antonio Luque, eds. Smart sensors and MEMS: Intelligent sensing devices and microsystems for industrial applications. Woodhead Publishing, 2018.

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

**List of Experiments**

| | | |
|---|---|---|
| 1 | Characteristics of Thermistor | **2 hours** |
| 2 | Characteristics of Strain Gauge | **2 hours** |
| 3 | Characteristics of Light Dependent Resistor | **2 hours** |
| 4 | Characteristics of Resistance Temperature Detector | **2 hours** |
| 5 | Characteristics of Angular potentiometer transducer model. | **2 hours** |
| 6 | Characteristics of LVDT | **2 hours** |
| 7 | Characteristics of Capacitive Level Sensor | **2 hours** |
| 8 | Characteristics of Thermocouples | **2 hours** |
| 9 | Characteristics of Photoelectric Tachometer | **2 hours** |
| 10 | Calibration of RTD and signal conditioning of RTD | **2 hours** |
| 11 | Calibration of Thermistor and signal conditioning of thermistor | **2 hours** |
| 12 | Characteristics of piezoelectric and Hall effect sensors | **2 hours** |

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|---|---|---|---|---|
| 13 | Simulation of Biosensors/Chemical Sensors | | | **2 hours** |
| 14 | Simulation and design of sensors using MATLAB/LABVIEW/ COMSOL | | | **2 hours** |
| 15 | PC based Data acquisition system. | | | **2 hours** |
| | | | **Total Laboratory Hours** | **30 hours** |
| Mode of assessment: Continuous assessment &Final Assessment Test (FAT) | | | | |
| Recommended by Board of Studies | 28-02-2023 | | | |
| Approved by Academic Council | No. 69 | Date | 16-03-2023 | |

| Course Code | Course Title | | L | T | P | C |
|---|---|---|---|---|---|---|
| BECE410L | Micro-Electromechanical Systems | | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | | |
| | | 1.0 | | | | |

**Course Objectives**

The course is aimed to
1. Introduce MEMS technology and their application as Sensors and actuators.
2. Comprehending various materials used in MEMS devices and also Micro-Nano fabrication techniques involved.

**Course Outcomes**

Students will be able to
1. Analyze the evolution of MEMS in various applications along with the scaling effects.
2. Understand the rudiments of materials like silicon, polymers, and metals used for realizing MEMS sensors.
3. Explore various fabrication techniques for MEMS devices
4. Analyze various sensing mechanisms and applications based on the same
5. Analyze various actuating mechanisms and applications based on the same
6. Acquaint the basics of Bio-MEMS and simple application models of BioMEMS
7. Understand flexible, printable types of devices and their applications

| Module: 1 | Micro-electro Mechanical Systems (MEMS) | 5 hours |
|---|---|---|

Historical background and evolution of Micro Electro Mechanical Systems (MEMS); Market for MEMS sensors -Real-world sensor/actuator examples; MEMS sensors in automobiles, smartphones, and Bio-medical applications.
Scaling in MEMS - Scaling of length, surface area, and volume — Scaling and surface tension -Scaling in optics - Scaling in the electrostatic and electromagnetic domain, Thermal domain - Scaling in microfluidics.

| Module: 2 | MEMS Materials and Properties | 6 hours |
|---|---|---|

Crystal, Substrates and wafers, Silicon and Silicon compounds - Silicon oxide and nitride; Single Crystal Silicon growth (CZ and FZ methods); Thin metal films (Cr, Au, Ti, Pt) — Polymers (SU8, PMMA, PDMS); Glass and Quartz; Paper; Nanoparticles – CNTs – Graphene - $MoS_2$; Choice and role of these substrates and materials in realizing miniature sensors.
Important material properties-Young modulus - Poisson's ratio - Density - Piezoresistive coefficients - Piezoelectric coefficients- TCR - Thermal conductivity - Material structure.

| Module: 3 | MEMS Fabrication Technology | 7 hours |
|---|---|---|

Silicon Wafer Cleaning - Oxidation - PVD (Thermal and E-beam evaporation, sputtering) - CVD - Lithography - Bulk- and surface-micromachining - LIGA - Bonding, and Packaging.
Surface Modification Techniques for Polymers, Soft-Lithography; Micro molding; Replica molding, and Micro contact printing.
Patterning Processes for flexible sensors - Printing technology, Non-Contact Type-Jet printing, Contact type - Screen printing, Gravure printing.

| Module:4 | Sensing Mechanisms and MEMS Sensors | 7 hours |
|---|---|---|

**Sensing mechanisms** – Capacitive, Piezoelectric, Piezoresistive, Electromagnetic, Optical, and Resonant sensing principles

| | | |
|---|---|---|
| **MEMS Sensors:** Pressure sensors, Accelerometers, Gas sensors, Flow sensors, Gyroscopes, Microcantilevers as sensors, Imaging and displays, and Fiber-optic communication devices. | | |
| **Module:5** | **Actuation Mechanisms and MEMS Actuators** | **7 hours** |
| **Actuation Mechanisms:** Electrostatic, Piezoelectric, Electrothermal, Shape memory alloy (SMA)<br>**MEMS actuators:** Microcantilever as actuators, Micro resonator, Microgripper, Micromirror, Micro motor, RF MEMS switch, Phase shifter, Varactor, and Micro heater. | | |
| **Module:6** | **BioMEMS** | **6 hours** |
| Glucose sensors, In Vitro and In Vivo diagnostics, µ-TAS - Micromixer, Micro Valve, Micro Pump, Drug delivery systems, and MEMS. Application models – Implantable Biochips – Micro needles – Microelectrodes - Neural prosthesis and catheter end sensors, Paper-based microfluidic devices as biosensors. | | |
| **Module:7** | **Flexible and Wearable Sensors** | **5 hours** |
| Textiles and polymers-based flexible sensors and applications – ECG, Blood Pressure, Epidermal Sensors, Tattoo based sensors, haptic gloves, strain sensors, pH sensors, and physiological sensors. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
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| | | |
| | **Total Lecture hours:** | **45 hours** |

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|---|---|
| **Text Book(s)** | |
| 1. | Tai-Ran Hsu, MEMS and Microsystems Design and Manufacture, 2017, 1st edition, Tata McGraw-Hill Publishing Company Ltd., India. |
| **Reference Books** | |
| 1. | Run-Wei Li, Gang Liu , Flexible and Stretchable Electronics Materials, Designs, and Devices – 2019, Taylor and Francis, Singapore |
| 2. | Marc J. Madou, Fundamentals of Microfabrication and Nanotechnology, 2018, CRC Press |
| 3 | Chang Liu , Foundations of MEMS, 2016, Pearson India |
| Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz, and Final Assessment Test | |

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

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| BECE411L | Cryptography and Network Security | 3 | 0 | 0 | 3 |
| Pre-requisite | BECE401L, BECE401P/ BCSE308L, BCSE308P | Syllabus Version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. To acquaint students with the basic concepts in need for security mechanism, classical and traditional Encryption techniques.
2. To impart knowledge to students regarding the significance of message confidentiality, Integrity and availability using Cryptography.
3. To acquaint the students to the different types of network & internet security and its significance.

**Course Outcomes**

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

1. Analyze OSI Security Architecture and Classical Encryptions.
2. Realize the various mathematical techniques in cryptography, including number theory, Finite Field, modulo operator, Elliptic Curve Arithmetic and Discrete Logarithm.
3. Analyze Modern block and stream ciphers, Data Encryption Standard (DES), Advanced Encryption Standard (AES), IDEA and Key Exchange Algorithms.
4. Analyze Asymmetric ciphers: RSA, ElGamal, RABIN Cryptosystem.
5. Comprehend the various types of data integrity and authentication schemes.
6. Infer the various network and Internet security mechanisms.

| Module | Title | Hours |
|---|---|---|
| Module:1 | Cryptography: Overview | 4 hours |
| Introduction, OSI Security Architecture, Security Attacks, Security Services and Mechanisms, Classical Encryption Techniques. | | |
| Module:2 | Mathematical Foundations | 6 hours |
| Number Theory and Finite Fields (Group, Ring and Fields), Fermat's and Euler's Theorems, The Chinese Remainder Theorem, Fast Exponentiation, Discrete Logarithms, Elliptic Curve Arithmetic, and Principles of Pseudorandom Number Generation. | | |
| Module:3 | Symmetric Ciphers | 8 hours |
| Modern Block Ciphers and Modern Stream Ciphers- DES, IDEA, AES, Pseudorandom Number Generation based on symmetric cipher, Key Exchange Algorithm: Diffie-Hellman Key Exchange. | | |
| Module:4 | Asymmetric Ciphers | 7 hours |
| RSA cryptosystem, ElGamal Cryptosystem, RABIN Cryptosystem, Elliptic Curve Cryptography simulating Elgamal, Pseudorandom Number Generation based on an asymmetric Cipher. | | |
| Module:5 | Data Integrity Algorithms | 7 hours |
| Cryptographic Hash Functions: MD4, SHA-512, Whirlpool, Message Authentication Codes, Digital Signatures: RSA, Elgamal, Schnorr, DSS. | | |
| Module:6 | Mutual Trust | 5 hours |
| Key Management and Distribution, X.509, User Authentication Protocols, Kerberos. | | |
| Module:7 | Network and Internet Security | 6 hours |
| Transport Layer Security, Wireless LAN Security, Electronic mail Security, Firewalls, IoT Threats. | | |

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

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|---|---|
| **Text Book(s)** | |
| 1. | William Stallings, "Cryptography and Network security: Principles and Practice", 8th Edition, 2020, Pearson Education, India. |
| **Reference Books** | |
| 1. | Atul Kahate, “Cryptography And Network Security”, 4th Edition, 2019, The McGraw Hill Company. |
| 2 | Behrouz A.Forouzan, Debdeep Mukhopadhyay “Cryptography & Network Security”, 3rd edition, 2015, The McGraw Hill Company. |
| | |

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

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

| **Course Code** | **Course Title** | | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|---|
| **BECE399J** | **Summer Industrial Internship** | | **0** | **0** | **0** | **1** |
| **Pre-requisite** | **NIL** | **Syllabus version** | | | | |
| | | **1.0** | | | | |

**Course Objectives**

1. The course is designed so as to expose the students to industry environment and to take up on-site assignment as trainees or interns.

**Course Outcomes**

1. Demonstrate professional and ethical responsibility.
2. Understand the impact of engineering solutions in a global, economic, environmental and societal context.
3. Develop the ability to engage in research and to involve in life-long learning.
4. Comprehend contemporary issues.

| **Module Content** | **4 Weeks (28 hours)** |
|---|---|

Four weeks of work at industry site.
Supervised by an expert at the industry.

**Mode of Evaluation:** Internship Report, Presentation and Project Review

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|---|---|---|---|
| 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.

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| 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.

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|---|---|---|---|
| Recommended by Board of Studies | 12-10-2022 | | |
| Approved by Academic Council | No. 68 | Date | 19-12-2022 |