

Silicon Institute of Technology
| An Autonomous Institute |

Curriculum Structure and Detailed Syllabus

Bachelor of Technology in Electronics & Communication Engineering



**Department of Electronics & Communication Engineering
Silicon Institute of Technology
Silicon Hills, Patia, Bhubaneswar - 751024**

Effective From Academic Year 2021-22

Version: 2.10 (Build: 14-04-2023)

Approval History

| ACM# | Date | Resolutions |
|------|------------|---|
| AC-6 | 09/10/2021 | The curriculum structure and detailed syllabus of 1st Year as proposed by the Boards of Studies is approved by the Academic Council. |
| AC-8 | 13/08/2022 | The curriculum structure and detailed syllabus of 2nd, 3rd, and 4th years as proposed by the Boards of Studies is approved by the Academic Council. |

Program Outcomes (UG Engineering)

Graduates Attributes (GAs) form a set of individually assessable outcomes that are the components indicative of the graduate's potential to acquire competence to practice at the appropriate level. The Program Outcomes (POs) for UG Engineering programmes defined by NBA are:

- PO1. **Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
- PO2. **Problem Analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- PO3. **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.
- PO4. **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.
- PO5. **Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- PO6. **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.
- PO7. **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.
- PO8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- PO9. **Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- PO10. **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.
- PO11. **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.
- PO12. **Life-long Learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

- PSO1. Understand, analyze and apply the elementary concepts in Electronics and Communication Engineering to design, formulate and implement efficient systems in the broad areas related to signal processing, image processing, communication, VLSI and embedded systems.
- PSO2. Develop the skills in modern technologies, tools & platforms to become a successful professional or entrepreneur, exhibit a passion for innovation & higher studies, and contribute as a responsible citizen with effective communication, strong moral values & professional ethics.
- PSO3. Embrace various technological advancements in electronics & communication to design and create useful and competitive systems for real-world needs using modern platforms and tools to meet future challenges.

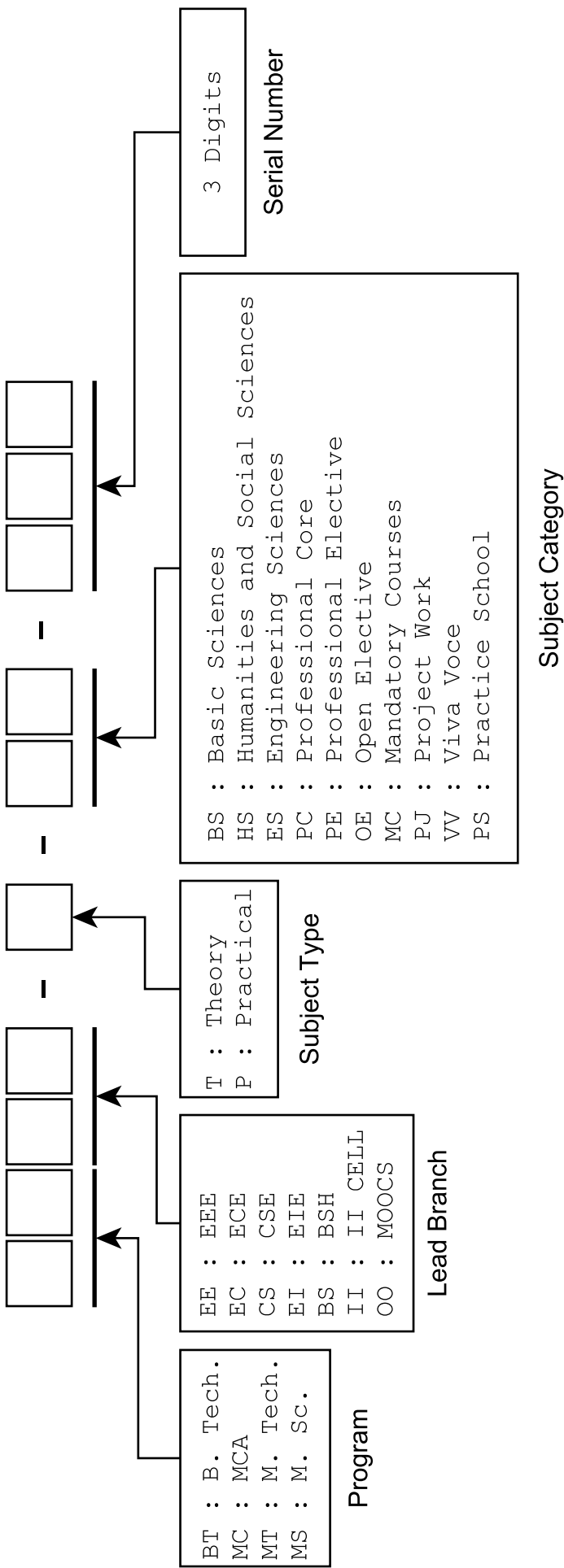
Program Educational Objectives (PEOs)

- PEO1. *Fundamental Knowledge & Core Competence:* To utilize the knowledge of mathematics, science and fundamentals of electronics & communication engineering required to become a successful professional and foster complex problem solving ability.
- PEO2. *Proficiency for the Real World:* To acquire the skills to analyze, design, develop, and optimize novel acceptable electronics and communication systems as per the growing needs of the real world.
- PEO3. *Leadership & Social Responsibility:* To exhibit leadership capability with professional, ethical, interpersonal skills, social & economic commitment with a sense of responsibility towards public policies, community services, humanity and environment.
- PEO4. *Life-long Learning:* To grow professionally through continued education & training of technical and management skills, pursue higher studies, and engage in life-long learning.

Course Types & Definitions

| | |
|-----|---|
| L | Lecture |
| T | Tutorial |
| P | Laboratory / Practical / Sessional |
| WCH | Weekly Contact Hours |
| BS | Basic Sciences |
| HS | Humanities & Social Sciences (including Management) |
| ES | Engineering Sciences |
| PC | Professional Core |
| PE | Professional Elective |
| OE | Open Elective |
| MC | Mandatory Course |
| OO | Massive Open Online Course (MOOC) - Self Study |
| PJ | Summer Internship / Project Work / Seminar |
| PS | Practice School / Industry Internship |
| VV | Viva Voce |

Subject Code Format



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Part I

1st Year B. Tech.
(Common to All Branches)

Induction Program

It is necessary for a newly admitted student to acclimatize to the environment of a college, create a bonding between the teacher and students, equip the students with communication skills, and get them acquainted with the academic & disciplined culture of institution & human values.

All students admitted to B.Tech. programs shall undergo a mandatory induction program after joining the institute and before the commencement of classes. Regular classes of the engineering programs shall begin only after the students have completed the induction program.

The induction program shall comprise of familiarization to the rules & regulations of the institute, examinations & evaluation system, departments/branches, campus facilities, official processes & important officials, curricular/ co-curricular/ extra-curricular activity clubs, innovation & research activities, etc. The program shall also comprise of lectures by eminent persons on adopting a disciplined & healthy life-style, career planning & emerging technologies, social awareness, human values & ethics to sensitize & motivate the students to become not only a successful engineer, but also a socially responsible citizen and contribute their part for social development and nation building.

Interaction with faculty advisors, mentors, senior students, individual/group physical activities, learning or exhibiting an art form/ literature, social service initiatives, and visits to important places of the city, and any other events/ activities deemed to be necessary, may also be included in the induction program.

Every new student must diligently attend & participate in all the activities of the induction program. Attendance in the activities shall be recorded. Students have to submit a daily report in prescribed format to the concerned faculty advisor on the next day. There will be a computer-based test with multiple-choice questions on a suitable date about a week after completion of the induction program.

Evaluation of Induction Program shall be done out of 100 marks, comprising of 3 components, namely: (i) 25 marks for attendance, (ii) 25 marks for the daily reports, and (iii) 50 marks for the computer-based multiple-choice test. A student has to score at least 50 marks in total to pass the induction program.

In case of failure, the student has to attend the induction program in the next academic year along with the newly admitted students, submit daily reports, and appear the computer-based test to score a pass mark.

Curriculum Structure

| Semester I | | | | | | | | |
|------------|---------------------------------|--|--------------|---|----|------------------|---|---|
| Type | Code | Course Title | WCH L-T-P | | | Credits L-T-P | | |
| THEORY | | | | | | | | |
| BS | BTBS-T-BS-005 | Engineering Mathematics-I | 3 | 0 | 0 | 3 | 0 | 0 |
| BS | BTBS-T-BS-002/ BTBS-T-BS-006 | Engineering Chemistry / Engineering Physics | 3 | 0 | 0 | 3 | 0 | 0 |
| ES | BTEC-T-ES-001/ BTEE-T-ES-001 | Basic Electronics Engineering/ Basic Electrical Engineering | 2 | 0 | 0 | 2 | 0 | 0 |
| ES | BTCS-T-ES-001 | Computer Programming | 3 | 0 | 0 | 3 | 0 | 0 |
| MC | BTBS-T-MC-001/ BTBS-T-MC-008 | Constitution of India/ Environmental Science & Engineering | 2 | 0 | 0 | 0 | 0 | 0 |
| PRACTICAL | | | | | | | | |
| BS | BTBS-P-BS-003/ BTBS-P-BS-007 | Engineering Chemistry Lab/ Engineering Physics Lab | 0 | 0 | 2 | 0 | 0 | 1 |
| ES | BTBS-P-ES-009/ BTBS-P-ES-004 | Manufacturing Practices/ Engineering Graphics | 0 | 0 | 2 | 0 | 0 | 1 |
| ES | BTEC-P-ES-002/ BTEE-P-ES-002 | Basic Electronics Engineering Lab/ Basic Electrical Engineering Lab | 0 | 0 | 2 | 0 | 0 | 1 |
| ES | BTCS-P-ES-002 | Computer Programming Lab | 0 | 0 | 4 | 0 | 0 | 2 |
| | | SUB-TOTAL | 13 | 0 | 10 | 11 | 0 | 5 |
| | | TOTAL | 23 | | | 16 | | |

Note: For some courses, the subjects have been mentioned as Subject-1 / Subject-2, i.e., with an OR option. Every student has to study both the subjects, however allocation of these subjects shall alternate between Semesters I and II. For example, if a student has been allocated *Engineering Chemistry* in Semester-I, then he/she will be allocated *Engineering Physics* in Semester-II, and vice-versa. The laboratory subjects will be as per the theory subjects allocated in the applicable semester. The same applies to all other courses provided with an OR option.

| Semester II | | | | | | | | |
|-------------|---------------------------------|--|--------------|---|----|------------------|---|---|
| Type | Code | Course Title | WCH L-T-P | | | Credits L-T-P | | |
| THEORY | | | | | | | | |
| BS | BTBS-T-BS-013 | Engineering Mathematics-II | 3 | 0 | 0 | 3 | 0 | 0 |
| BS | BTBS-T-BS-006/ BTBS-T-BS-002 | Engineering Physics/ Engineering Chemistry | 3 | 0 | 0 | 3 | 0 | 0 |
| ES | BTEE-T-ES-001/ BTEC-T-ES-001 | Basic Electrical Engineering/ Basic Electronics Engineering | 2 | 0 | 0 | 2 | 0 | 0 |
| ES | BTCS-T-ES-003 | Data Structures & Algorithms | 3 | 0 | 0 | 3 | 0 | 0 |
| MC | BTBS-T-MC-008/ BTBS-T-MC-001 | Environmental Science & Engineering/ Constitution of India | 2 | 0 | 0 | 0 | 0 | 0 |
| HS | BTBS-T-HS-099 | Communicative & Technical English | 2 | 0 | 0 | 2 | 0 | 0 |
| PRACTICAL | | | | | | | | |
| BS | BTBS-P-BS-007/ BTBS-P-BS-003 | Engineering Physics Lab/ Engineering Chemistry Lab | 0 | 0 | 2 | 0 | 0 | 1 |
| ES | BTBS-P-ES-004/ BTBS-P-ES-009 | Engineering Graphics/ Manufacturing Practices | 0 | 0 | 2 | 0 | 0 | 1 |
| ES | BTEE-P-ES-002/ BTEC-P-ES-002 | Basic Electrical Engineering Lab/ Basic Electronics Engineering Lab | 0 | 0 | 2 | 0 | 0 | 1 |
| ES | BTCS-P-ES-004 | Data Structures & Algorithms Lab | 0 | 0 | 4 | 0 | 0 | 2 |
| HS | BTBS-P-HS-011 | Communicative & Technical English Lab | 0 | 0 | 2 | 0 | 0 | 1 |
| | | SUB-TOTAL | 15 | 0 | 12 | 13 | 0 | 6 |
| | | TOTAL | 27 | | | 19 | | |

Note: For some courses, the subjects have been mentioned as Subject-1 / Subject-2, i.e., with an OR option. Every student has to study both the subjects, however allocation of these subjects shall alternate between Semesters I and II. For example, if a student has been allocated *Engineering Chemistry* in Semester-I, then he/she will be allocated *Engineering Physics* in Semester-II, and vice-versa. The laboratory subjects will be as per the theory subjects allocated in the applicable semester. The same applies to all other courses provided with an OR option.

| Type | Code | Engineering Mathematics - I | L-T-P | Credits | Marks |
|------|---------------|-----------------------------|-------|---------|-------|
| BS | BTBS-T-BS-005 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to familiarize the students with the knowledge and concepts of curve tracing, ordinary differential equations and applications, solution of system of linear equations using matrix methods, and Eigen vectors & Eigen values of matrices with applications. |
| Pre-Requisites | A good knowledge of trigonometry along with basics of differential and integral calculus of one variable and coordinate geometry of two and three dimensions. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Functions and their Graphs, Asymptotes & Curvature (concepts only), Geometric meaning of $y' = f(x, y)$ & direction fields, Separable ordinary differential equations (ODE) and Modeling. | 8 Hours |
| Module-2 | Exact ODE & Integrating Factor, Linear ODE, Bernoulli's Equation and Population models, Modeling electrical circuits, Homogeneous linear ODE of second order, Second order Linear ODE with constant coefficients, Modeling free oscillation. | 8 Hours |
| Module-3 | Euler-Cauchy ODE, Non-homogeneous linear ODE and applications to electrical circuits. | 7 Hours |
| Module-4 | Matrix algebra, system of linear equations, rank and inverse of matrices, vector space. | 8 Hours |
| Module-5 | Eigen values and Eigen vectors, Complex matrices, Diagonalization of matrices. Positive Definite Matrix, Singular Value Decomposition (SVD) and Pseudo Inverse. | 11 Hours |
| Total | | 42 Hours |

Text Books:

- T1. S. Narayan and P. K. Mittal, *Differential Calculus*, Revised Edition, S. Chand & Company, 2014.
- T2. E. Kreyszig, *Advanced Engineering Mathematics*, 8th Edition, Wiley India, 2015.
- T3. G. Strang, *Linear Algebra and Its Applications*, 4th Edition, Cengage Learning, 2015.

Reference Books:

- R1. S. Pal and S. C. Bhunia, *Engineering Mathematics*, 1st Edition, Oxford University Press, 2015.
- R2. B. V. Ramana, *Higher Engineering Mathematics*, 1st Edition, McGraw Hill, 2017.

Online Resources:

1. <http://www.nptel.ac.in/courses/111105035>
2. <http://www.nptel.ac.in/courses/122104017>
3. <http://nptel.ac.in/courses/122102009>

4. <http://nptel.ac.in/courses/111107063>
5. <https://www.coursera.org/learn/linearalgebra2>
6. <https://www.coursera.org/learn/differentiation-calculus>
7. <https://www.coursera.org/learn/single-variable-calculus>
8. <https://alison.com/courses/Algebra-Functions-Expressions-and-Equations>

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

| | |
|-----|--|
| CO1 | Describe graphs of functions (curves) and their characteristics like asymptotes and curvature. |
| CO2 | Solve first order ordinary differential equations using various methods and apply them to find solutions of physical problems. |
| CO3 | Explain the methodology to solve second order ordinary differential equations and apply them to solve applied problems of electrical circuits. |
| CO4 | Explore the concepts and methods of system of linear equations to solve a system. |
| CO5 | Use the eigen values and eigen vectors of matrices, its properties and applications of SVD. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Engineering Chemistry | L-T-P | Credits | Marks |
|------|---------------|-----------------------|-------|---------|-------|
| BS | BTBS-T-BS-002 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The purpose of this course is to emphasize the relevance of fundamentals and applications of chemical sciences in the field of engineering. The course attempts to address the principles of general chemistry and specific topics relevant to various engineering disciplines, so that the students can apply the knowledge in their respective areas of expertise. |
| Pre-Requisites | Basic knowledge on Normality, Molarity, mole concept, types of chemical reactions, and elementary idea on electrochemistry. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|----------|
| | Introduction & Pre-requisites | 2 Hours |
| Module-1 | Water Treatments: Types of hardness-Units, Alkalinity of water and its significance, Softening methods and Numerical problems based on these methods; Membrane-based processes; Dissolved Oxygen, Problems with Boiler feed water and its treatments. | 8 Hours |
| Module-2 | Corrosion Science: Definition and scope of corrosion, Dry and wet corrosion; Direct chemical corrosion, Electrochemical corrosion and its mechanisms; Types of electrochemical corrosion, (differential aeration, galvanic, concentration cell); Typical Electrochemical corrosion like Pitting, Inter-granular, Soil, Waterline; Factors affecting corrosion, Protection of corrosion. | 7 Hours |
| Module-3 | Instrumental Techniques: Fundamentals of Spectroscopy; Principles and applications of molecular spectroscopy (such as UV-visible, IR and microwave). | 8 Hours |
| Module-4 | Energy Sciences: Types of fuels, Calorific value, Determination of Calorific value, Combustion and its calculations, Solid fuel: Coal analysis (Proximate and ultimate analysis), Elementary ideas on some gaseous fuels (Natural gas, Water gas, Producer gas, LPG) (Synthesis is excluded), Liquid fuels: IC engine fuel, concept of knocking, antiknocking, octane No and cetane No, Fractional Distillation of petroleum, Cracking of heavy oils; Battery technology – Fundamentals of primary & Secondary cells, Rechargeable batteries: Lead acid storage battery, Lithium ion battery, Fuel cells: principles, applications. Elementary idea on Photovoltaics. | 10 Hours |

Cont'd...

| Module-# | Topics | Hours |
|----------|--|----------|
| Module-5 | Nanochemistry: Nanomaterials, Classification of nanomaterials, Synthesis of noble metal nanoparticles (e.g., Gold /silver) and oxide based nanoparticles (e.g., cuprous oxide/zinc oxide) using green synthetic route, Stabilization of nanoparticles using capping agents, Elementary ideas on characterization of nanoparticles (X-ray Diffraction (XRD) and electronic spectroscopy), applications of nanomaterials. | 7 Hours |
| Total | | 42 Hours |

Text Books:

- T1. Jain & Jain, *Engineering Chemistry*, 16th Edition, Dhanpat Rai Publishing Company, 2015.
 T2. Wiley-India Editorial Team, *Engineering Chemistry*, 2nd Edition, Wiley India, 2011.
 T3. C. N. Banwell, *Fundamentals of Molecular Spectroscopy*, 4th Edition, McGraw Hill Education, 2017.

Reference Books:

- R1. S. S. Dara, *Engineering Chemistry*, 12th Edition, S. Chand Publisher, 2014.
 R2. G. A. Ozin & A. C. Arsenault, *Nanochemistry - A Chemical Approach to Nanomaterials*, 2nd Edition, RSC Publishing, 2008.
 R3. J. M. Lehn, L. Cademartiri, *Concepts of Nanochemistry*, 1st Edition, Wiley-VCH, 2009.
 R4. Y. R. Sharma, *Elementary Organic Spectroscopy*, S Chand & Co Ltd., 2013.

Online Resources:

- https://chem.libretexts.org/Core/Analytical_Chemistry/Electrochemistry/Exemplars/Corrosion/Corrosion_Basics
- <https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/spectrpy/infrared/infrared.htm>
- <http://nptel.ac.in/courses/103105110/> - Fuel & Combustion
- <http://nptel.ac.in/courses/105104102/hardness.htm>
- http://nptel.ac.in/courses/105106112/1.introduction/5_corrosion.pdf
- <https://alison.com> - Spectroscopic Technique, Colorimetry

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

| | |
|-----|---|
| CO1 | Exploit the concept of hardness in softening hard water and determining the hardness of water. |
| CO2 | Utilize the knowledge of electrochemistry and corrosion science in preventing engineering equipments from corrosion. |
| CO3 | Apply the concept of molecular spectroscopy to analyze organic compounds using spectrophotometer. |
| CO4 | Classify various fuels based on combustion parameters and understand the working principle of various batteries. |
| CO5 | Acquire knowledge on synthesis & characterization of oxide based & noble metal nanoparticles through green synthetic route. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |

Cont'd...

| | |
|-----|--|
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO7 | 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. |
| PO8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Engineering Physics | L-T-P | Credits | Marks |
|------|---------------|---------------------|-------|---------|-------|
| BS | BTBS-T-BS-006 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to obtain basic idea about various laws and understand different phenomena using principles of physics. This knowledge will be useful for the engineering students to understand the basic operating principle of instruments and techniques. The knowledge obtained can also be used to prepare various models and projects. |
| Pre-Requisites | Adequate knowledge and clear concepts in higher secondary physics like waves, oscillations, optics, electricity, magnetism, modern physics, etc. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|----------|
| | Introduction & Pre-requisites | 2 Hours |
| Module-1 | Wave Optics: Concept of wave and wave equation, Superposition of waves (two beam and multiple beam) and interference, Huygen's principle, Interference by division of amplitude and division of wavefront, Theory of Newton's rings and its applications, Diffraction, Fraunhofer and Fresnel diffraction, Fraunhofer's diffraction from a single slit, Theory of plane diffraction grating, Determination of wavelength of light with a plane diffraction grating. | 10 Hours |
| Module-2 | Vector Calculus: Gradient of scalar field, Divergence and curl of vector field, Gauss divergence theorem and Stokes theorem (statement only). Maxwell's Equations: Gauss's law in electromagnetism, Faraday's law of electromagnetic induction, Ampere's circuital law, Displacement current, Maxwell's electromagnetic equations (integral and differential form). Electromagnetic Waves: Electromagnetic Wave (EM) equations - Free space, Dielectric and conducting medium, Transverse nature of EM wave, Electromagnetic wave in ionized medium, Electromagnetic energy density, Poynting's theorem and Poynting's vector. | 11 Hours |
| Module-3 | Introduction to Quantum Mechanics: Need of quantum mechanics, Particle nature of radiation - Black body radiation (no derivation), Photoelectric effect, Compton effect and pair production, Concept of de-Broglie's matter waves, Phase and group velocity, Heisenberg's Uncertainty principle with applications. | 6 Hours |
| Module-4 | Schrödinger's wave equation with applications: Concept of wave function ψ and interpretation of $ \psi ^2$, Schrödinger's time-dependent and time-independent equations, Probability current, Expectation values, Operators in quantum mechanics, Eigen functions and Eigen values, Applications of Schrödinger's equation- Particle in one dimensional rigid box, Potential barrier (emphasis on tunneling effect). | 6 Hours |

Cont'd...

| Module-# | Topics | Hours |
|----------|---|----------|
| Module-5 | Laser: Radiation-matter interaction, Absorption of light, Spontaneous and stimulated emission of light, Population inversion, Types of Laser-Solid State Laser (Ruby), Gas Laser (He-Ne), Properties and applications of Laser. Optical Fiber: Structure and Principle, Types of optical fiber, Numerical aperture, Applications of optical fiber. | 7 Hours |
| Total | | 42 Hours |

Text Books:

- T1. D. R. Joshi, *Engineering Physics*, 1st Edition, Tata McGraw-Hill Publication, 2017.
T2. Md. M. Khan and S. Panigrahi, *Principle of Physics*, Vol. I & II, Cambridge Univ. Press.

Reference Books:

- R1. A. Ghatak, *Optics*, Tata McGraw Hill.
R2. B. S. Agarwal, *Optics*, Kedar Nath Rama Nath & Co.
R3. S. Prakash, *Electromagnetic Theory and Electrodynamics*, Kedar Nath Ram Nath & Co.
R4. D. J. Griffith, *Introduction to Electrodynamics*, Pearson Education.
R5. R. Eisberg and R. Resnick, *Quantum Physics of Atoms, Molecules, Solids, Nuclei & Particles*, John Wiley Publications.
R6. A. Beiser, *Concept of Modern Physics*, McGraw Hill.
R7. R. K. Gour and S. L. Gupta, *Engineering Physics*, Dhanpat Rai Publications.

Online Resources:

- <https://ocw.mit.edu/courses/physics/8-04-quantum-physics-i-spring-2013/>
- <http://www.ilectureonline.com/lectures/subject/PHYSICS>
- <https://ocw.mit.edu/courses/physics>
- <https://nptel.ac.in/courses/115102026/>
- <https://nptel.ac.in/courses/113104012/>

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

| | |
|-----|---|
| CO1 | Analyze wave properties of light like interference and diffraction and apply them in communications |
| CO2 | Develop Maxwell's equations from basic laws of electromagnetism and apply them to understand the properties of electromagnetic waves. |
| CO3 | Analyze wave-particle duality to understand radiation-matter interaction |
| CO4 | Develop and apply Schrödinger's equations to diverse fields like bound particle, potential barrier etc. |
| CO5 | Investigate the basic principle, properties, operations and applications of laser & optical fibre in different fields like communication, industry, medicine, research etc. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |

Cont'd...

| | |
|------|--|
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Basic Electronics Engineering | L-T-P | Credits | Marks |
|------|---------------|-------------------------------|-------|---------|-------|
| ES | BTEC-T-ES-001 | | 2-0-0 | 2 | 100 |

| | |
|------------------------|---|
| Objectives | Know broadly the concepts and functionalities of the electronic devices, tools and instruments. Understand general specifications and deployability of the electronic devices, and assemblies. Develop confidence in handling and usage of electronic devices, tools and instruments in engineering applications. |
| Pre-Requisites | Knowledge on intrinsic and extrinsic Semiconductors, Physics and Chemistry of Higher Secondary Science level. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, and planned lectures to make the sessions interactive with problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Introduction to Electronics: Signals, Frequency spectrum of signals, Analog and digital signals; Diodes and Applications: Semiconductor Diode - Ideal versus Practical, Resistance Levels, Diode Equivalent Circuits, Load Line Analysis; Diode as a Switch, Diode as a Rectifier, Half Wave and Full Wave Rectifiers, Breakdown Mechanisms, Zener Diode – Operation and Applications; Clipper and Clamper Circuits, Diode applications. | 7 Hours |
| Module-2 | Bipolar Junction Transistor (BJT): Construction, Operation, Amplifying Action, Common Base, Common Emitter and Common Collector Configurations, Operating Point, Fixed and Voltage divider Biasing Configurations. | 6 Hours |
| Module-3 | Field Effect Transistor (FET): Construction, Characteristics of Junction FET (JFET), Depletion and Enhancement type Metal Oxide Semiconductor FETs (MOSFET), Introduction to Complementary MOS (CMOS) circuits. | 5 Hours |
| Module-4 | Operational Amplifiers and Applications: Introduction to Op-Amp, Differential Amplifier Configurations, Basics of Op-Amp, Characteristics of Ideal Op-Amp, CMRR, PSRR, Slew Rate; Block Diagram and Pin Configuration of IC 741 Op-Amp, Applications of Op-Amp as: Summing Amplifier, Difference Amplifier, Differentiator, Integrator. | 5 Hours |
| Module-5 | Feedback Amplifiers: Principle, Advantages of Negative Feedback, Different Feedback Topologies. Oscillators: Classification, RC Phase Shift Oscillator. | 5 Hours |
| Total | | 28 Hours |

Text Books:

- T1. R. L. Boylestad and L. Nashelsky, *Electronic Devices and Circuit Theory*, 11th Edition, Pearson Education, 2015.
- T2. A. S. Sedra and K. C. Smith, *Microelectronic Circuits*, 7th Edition, Oxford University Press, 2009.

Reference Books:

- R1. A. Agarwal and J. Lang, *Foundations of Analog and Digital Electronic Circuits*, 1st Edition, Morgan Kaufmann, 2005.
- R2. V. K. Mehta and R. Mehta, *Principles of Electronics*, 10th Rev. Edition, S. Chand Publishing, 2006.

Online Resources:

1. <https://nptel.ac.in/courses/117/103/117103063/>: by Prof. G. Barua, IIT Guwahati
2. <https://nptel.ac.in/courses/108/101/108101091/>: By Prof. M. B. Patil, IIT Bombay
3. <https://nptel.ac.in/courses/122/106/122106025/>: By Prof. T. S. Natarajan, IIT Madras
4. <https://nptel.ac.in/courses/117/107/117107095/>: Web Content by IIT Roorkee
5. <https://nptel.ac.in/courses/122/104/122104013/>: Web Content by IIT Kanpur

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

| | |
|-----|---|
| CO1 | Become familiar with basic signals, diodes and their applications. |
| CO2 | Investigate on the operation of different configurations of bipolar junction transistor. Analyze and design different biasing configurations with their applications. |
| CO3 | Understand the construction, operation and characteristics of JFET and MOSFET. Analyze and design different biasing configurations with their applications. |
| CO4 | Learn the construction and characteristics of Op-Amp and design circuits for various applications using Op-Amp. |
| CO5 | Understand different types of feedback topologies and design various kinds of oscillators. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Basic Electrical Engineering | L-T-P | Credits | Marks |
|------|---------------|------------------------------|-------|---------|-------|
| ES | BTEE-T-ES-001 | | 2-0-0 | 2 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to introduce the students to basic concepts of electricity and magnetism. The course will cover the basics of DC & AC networks, principle of operation of different electrical machines and measuring instruments. The course will train the students about the basic protection system and safety requirements and will give an overview of the electrical power systems. |
| Pre-Requisites | Basic knowledge of intermediate Physics, knowledge of basic Mathematics such as Calculus, Ordinary Differential Equations, Matrices etc. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Fundamentals of Electric Circuits: Charge & current, Voltage & current sources, Electrical circuit elements (R, L and C) and their characteristics, Kirchoff's current and voltage laws; Resistive Network Analysis: Node voltage & Mesh current analysis, Node voltage and mesh current analysis with controlled sources, Thevenin Theorem, Norton's Theorem, Principle of superposition, Maximum power transfer theorem; Formation of differential equation for RL & RC circuits; Concept of measurement and use of shunt and multipliers in ammeters and voltmeter. | 8 Hours |
| Module-2 | Representation of sinusoidal waveforms, Peak and rms values, Phasor representation, Real power, Reactive power, Apparent power, Power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel). | 6 Hours |
| Module-3 | Three phase balanced circuits, Voltage and current relations in star and delta connections. Brief introduction to generation, Transmission and Distribution of electrical power, Earthing & electrical safety. | 3 Hours |
| Module-4 | Electricity and magnetism, magnetic circuit and magnetic reluctance, Magnetic materials, BH characteristics, Ideal and practical transformer, e.m.f. equation of transformer, Equivalent circuit. | 4 Hours |
| Module-5 | Construction of D.C. machines, generator, Types of excitation system, working of D.C. motor, Classification of D.C. motor, Characteristics and speed control of dc motor; Generation of rotating magnetic fields, Construction and working of a three-phase induction motor, Torque-slip characteristic; Single-phase induction motor. | 7 Hours |
| Total | | 28 Hours |

Text Books:

- T1. E. Hughes, *Electrical & Electronic Technology*, 9th Edition, Pearson, 2004.
 T2. G. Rizzoni, *Principles and Applications of Electrical Engineering*, 5th Edition, McGraw Hill, 2006.

Reference Books:

- R1. A. E. Fitzgerald, D. E. Higginbotham, and A. Grabel, *Basic Electrical Engineering*, 5th Edition, Tata McGraw Hill.
- R2. B. L. Theraja and A. K. Theraja, *Textbook of Electrical Technology (Vol-I)*, 23rd Edition, S. Chand & Co.Ltd., 2002.
- R3. L. S. Bobrow, *Foundations of Electrical Engineering*, Asian Edition, Oxford Univ. Press, 2013.

Online Resources:

1. <https://nptel.ac.in/courses/108/105/108105053/>: by Prof. G. D. Roy, Prof. N. K. De, and Prof. T. K. Bhattacharya, IIT Kharagpur
2. <https://nptel.ac.in/courses/108/108/108108076/>: By Prof. L. Umanand, IISc Bangalore
3. <https://www.electrical4u.com/>

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

| | |
|-----|---|
| CO1 | Understand and analyze basic electrical network with D.C. source. |
| CO2 | Measure current, voltage and power of series RLC circuit excited by single-phase ac circuit. |
| CO3 | Analyze three phase electrical systems and develop an understanding of the real power system. |
| CO4 | Explain different concepts of magnetic fields and apply it to single phase transformer. |
| CO5 | Describe the working principles of rotating electrical machines. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO7 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Computer Programming | L-T-P | Credits | Marks |
|------|---------------|----------------------|-------|---------|-------|
| ES | BTCS-T-ES-001 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to introduce fundamentals of computer programming using the C programming language to the students. Starting with simple programs, the course will cover advanced topics like structures, pointers, file processing and pre-processor directives etc. and enable the students to write programs using C language for solving various engineering problems. |
| Pre-Requisites | Basic analytical and logical understanding including basic knowledge and usage of computers is required for this course. Prior experience with any other programming language will be beneficial. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Introduction to computers and programming, operating system, compilers, interpreters, algorithm, flowchart, pseudocode etc., structure of C program, character set, identifier, keywords, constants, variables, data types, operators, expressions, statements, operator precedence and associativity, type conversion, input/output statements. | 8 Hours |
| Module-2 | Decision making and branching: if, if-else, nested if-else, else-if ladder and switch constructs, iterative execution of code using loops: while, for, do-while, nested loops, controlling loop behavior using jump statements (break, continue, goto) and exit statements. | 8 Hours |
| Module-3 | Arrays (1-D & 2-D), declaration and initialization of arrays, accessing array elements, operations on arrays - insertion, deletion, searching, sorting (selection sort), merging etc., character arrays and strings, initialization, input & output of strings, operations on strings, array of strings, string handling functions. | 9 Hours |
| Module-4 | User-defined functions, declaration and definition, parameter passing by value, functions returning values, idea on call by reference, passing arrays to functions, recursion, storage classes - auto, register, static, extern, Structures and Unions - definition, initialization, accessing members, array of structures, arrays within structures, structures and functions, self-referential structures. | 9 Hours |
| Module-5 | Understanding pointers, declaration, initialization, accessing variables using pointers, pointer expressions, scale factor, chain of pointers, using pointers with arrays, strings, functions and structures, dynamic memory management, pre-processor directives, command line arguments, basics of file handling. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. E. Balagurusamy, *Programming in ANSI C*, 7th Edition, McGraw-Hill Education, 2017.
 T2. Y. Kanetkar, *Let Us C*, 16th Edition, BPB Publications, 2018.

Reference Books:

- R1. B. W. Kernighan and D. M. Ritchie, *The C Programming Language*, 2nd Edition, Pearson Education, 2015.
 R2. H. Schildt, *C: The Complete Reference*, 4th Edition, McGraw-Hill, 2017.
 R3. A. Kelley and I. Pohl, *A Book on C*, 4th Edition, Pearson Education, 2008.
 R4. B. Gottfried, *Schaum's Outline of Programming with C*, 3rd Edition, McGraw-Hill, 2017.

Online Resources:

1. <http://www.stat.cmu.edu/~hseltman/c/CTips.html>
2. <http://www.c-faq.com/>
3. <https://www.learn-c.org/>
4. <https://www.javatpoint.com/c-programming-language-tutorial>
5. <http://www2.its.strath.ac.uk/courses/c/>

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

| | |
|-----|---|
| CO1 | Formulate logic of a problem and write C programs using variables, expressions and input/output statements. |
| CO2 | Develop structured C programs involving decision making using different control constructs. |
| CO3 | Solve problems involving similar set of data items and convert them into C programs using arrays. |
| CO4 | Design modular C programs and handle heterogeneous data items using structures & unions. |
| CO5 | Write C applications using pointers, pre-processor directives, command line arguments and files. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO12 | 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. |

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Constitution of India | L-T-P | Credits | Marks |
|------|---------------|-----------------------|-------|---------|-------|
| MC | BTBS-T-MC-001 | | 2-0-0 | 0 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this subject is to provide understanding of the basic concepts of Indian Constitution and various organs created by the constitution including their functions. The course acquaints students with the constitutional design of state structures and institutions, and their actual working over time. |
| Pre-Requisites | Basic knowledge of Indian history, overall idea on India's political system. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required and each session is planned to be interactive. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Introduction to Indian Constitution, Historical perspective of the constitution of India. Preamble of Indian constitution, Salient features of Indian constitution, Fundamental rights, Fundamental Duties and its legal status, Directive principles of state policy-its importance and Implementation. | 8 Hours |
| Module-2 | Federal structure and distribution of legislative and financial powers between the Union and the States, The Union legislature - The Parliament - The Lok Sabha and the Rajya Sabha, Composition, powers and functions, Union executive, President of India (with powers and functions), Vice-President, The Council of Ministers and the Prime Minister - Powers and functions. | 6 Hours |
| Module-3 | State Government, The State Legislature - composition, powers and functions, State executive, Governor (with powers and functions). | 5 Hours |
| Module-4 | Amendment of the Constitutional Powers and Procedure, Emergency Provisions : National Emergency, President Rule, Financial Emergency. Scheme of the Fundamental Right to Equality Scheme of the Fundamental Right to certain Freedom under Article 19, Scope of the Right to Life and Personal Liberty under Article 21. Local Self Government - Constitutional Scheme in India. | 5 Hours |
| Module-5 | The Indian Judicial System - the Supreme Court and the High Court's composition, jurisdiction and functions, Judicial review, Judicial activism, independence of Judiciary in India. | 4 Hours |
| Total | | 28 Hours |

Text Books:

- T1. D. D. Basu, *Introduction of Constitution of India*, 22nd Edition, LexisNexis, 2015.
- T2. K. Subas, *An Introduction to India's Constitution and Constitutional Law*, 5th Edition, National Book Trust India, 2011.

P.T.O

Reference Books:

- R1. M. Laxmikanth, *Indian Polity*, 5th Edition, McGraw Hill, 2011.
 R2. P. M. Bakshi, *The Constitution of India*, 14th Edition, Universal Law Publishing Co, 2006.

Online Resources:

1. https://www.india.gov.in/sites/upload_files/npi/files/coi_part_full.pdf
2. <https://www.india.gov.in/my-government/constitution-india/constitution-india-full-text>
3. https://www.tutorialspoint.com/indian_polity/indian_polity_tutorial.pdf
4. <https://www.careerpower.in/wp-content/uploads/2016/03/SSC-POLITY-CIVICS-CAPSULE-2016.pdf>

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

| | |
|-----|---|
| CO1 | Provide basic information about Indian constitution and to analyze the legalities and related issues of drafting, adoption and enforcement of the Indian Constitution as a fundamental law of the nation and the provisions and privileges of Indian Citizenship. |
| CO2 | Understand and judiciously use the fundamental rights and privileges envisaged in the constitution propagating social harmony and equality and respecting the rights and liberties of other people. |
| CO3 | Analyze the major dimensions of Indian Political System and to contribute in protecting and preserving the sovereignty and integrity of India. |
| CO4 | Know the successful functioning of democracy in India and to respect the Constitutional Institutions like Judiciary, Executive and Legislature. |
| CO5 | Understand their obligations, responsibilities, privileges & rights, duties and the role that they have to play in deciding the Administrative Machinery of the country. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO4 | 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. |
| PO6 | 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. |
| PO7 | 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. |
| PO8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| PO9 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Environmental Science & Engineering | L-T-P | Credits | Marks |
|------|---------------|-------------------------------------|-------|---------|-------|
| MC | BTBS-T-MC-008 | | 2-0-0 | 0 | 100 |

| | |
|------------------------|--|
| Objectives | This course serves as a general introduction to environmental science. From ecology and ecosystems, it acquaints the students to air & water quality and the impact of pollution on the environment due to industries and urbanization. Some remediation methods of minimizing the impact of pollutants through technology and legal systems are also addressed. |
| Pre-Requisites | Basic knowledge of physics, chemistry and biology is required for this course. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required and some sessions are planned for expert talk, seminar presentation by students. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Ecology & Biogeochemical Cycles: Introduction to environmental science, ecological perspective and value of environment, biodiversity of species, biotic components, energy, food chain, biogeochemical cycles like water, oxygen, nitrogen and carbon cycle. | 6 Hours |
| Module-2 | Water & Wastewater Treatment: Water quality standards and parameters, pre-treatment and conventional treatment processes of water, DO, BOD, COD, wastewater treatment. | 6 Hours |
| Module-3 | Atmospheric chemistry, soil chemistry, ground water recharge, noise source & abatement: atmospheric chemistry, air pollution, climate change, soil chemistry, water table and aquifer, ground water recharge, noise standards, noise measurement, noise control and activities including expert talk. | 5 Hours |
| Module-4 | Waste Management: Municipal Solid Waste (MSW), Hazardous waste and e-waste handling & management, Introduction to Life Cycle Assessment (LCA), Environmental Impact Assessment (EIA), Environmental Impact Statement (EIS). | 6 Hours |
| Module-5 | Environmental gradients & Laws: Environmental gradients, tolerance levels of environment factors, Indian environmental laws, Human population & the environment, Activities including seminar presentations by students. | 5 Hours |
| Total | | 28 Hours |

Text Books:

- T1. G. M. Masters and W. P. Ela, *An Introduction to Environmental Engineering and Science*, 3rd Edition, PHI Learning, 2015.
- T2. G. Kiely, *Environmental Engineering*, Spl. Indian Edition, McGraw Hill, 2007.

Reference Books:

- R1. M. L. Davis and S. J. Masten, *Principles of Environmental Engineering and Science*, 2nd Edition, McGraw-Hill, 2017.
- R2. H. D. Kumar and U. N. Dash, *Environmental Studies*, 2nd Edition, IndiaTech Publishers, 2017.

Online Resources:

1. <http://nptel.ac.in/courses/120108002/>: Aquatic Biodiversity and Environmental Pollution.
2. <http://nptel.ac.in/courses/120108004/>: Environment Management.
3. <http://nptel.ac.in/courses/120108005/>: Municipal Solid Waste Management.
4. <https://www.epa.gov/environmental-topics/>: All Current Environmental Issues.

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

| | |
|-----|--|
| CO1 | Apply concepts of ecology, eco systems, food chain and biogeochemical cycles for better understanding of functions of the environment. |
| CO2 | Enhance knowledge of water and wastewater treatment for prevention of water pollution. |
| CO3 | Understand the chemistry of pollutants in the atmosphere, soil and groundwater and understand principles of noise abatement. |
| CO4 | Enhance knowledge of waste minimization technique to minimize and manage solid, hazardous wastes generated in different areas. |
| CO5 | Understand environmental gradients, tolerance levels and environmental laws for prevention of environmental pollution. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO6 | 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. |
| PO7 | 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. |
| PO8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| PO9 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO11 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Engineering Mathematics - II | L-T-P | Credits | Marks |
|------|---------------|------------------------------|-------|---------|-------|
| BS | BTBS-T-BS-013 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to familiarize the perspective engineers with the knowledge and concepts of probability and statistics which are essential to study non-deterministic systems. |
| Pre-Requisites | Basics of sets, counting techniques, differential and integral calculus of one variable and coordinate geometry of two and three dimensions. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Measures of central tendencies, Elementary probability, Conditional probability, Bayes' Rule (related problems only), Random variable, Binomial & Hypergeometric distribution, Mean and variance, Chebyshev's Theorem. | 9 Hours |
| Module-2 | The Poisson approximation to Binomial Distribution, Poisson Process, Geometric Distribution & Multinomial Distribution, Continuous random variables, Normal Distribution, Normal Approximation to the Binomial Distribution, Uniform Distribution, Exponential Distribution, Joint Discrete Distribution. | 9 Hours |
| Module-3 | Populations and Samples, Sampling Distribution of Mean (σ known), Sampling Distribution of Mean (σ unknown) & Sampling Distribution of Variance; Point Estimation of mean, Interval Estimation of mean, Tests of hypotheses and errors involved, Hypotheses concerning one mean, Inference concerning two mean, Estimation of variance, Hypotheses concerning one variance, Hypotheses concerning two variances. | 8 Hours |
| Module-4 | Estimation of Proportions, Hypotheses Concerning proportion (one & several), Analysis of $r \times c$ table (Contingency table), Goodness of fit, Application of goodness of fit, Kolmogorov-Smirnov test. | 7 Hours |
| Module-5 | The method of least squares, Inferences based on the least square estimation, Curvilinear Regression, Multiple Regression, Checking the adequacy of the model, Correlation, Multiple linear regression (matrix notation); Analysis of Variance, General principle, Completely Randomized Design, Randomized Block Design. | 9 Hours |
| Total | | 42 Hours |

Text Books:

- T1. R. A. Johnson, *Miller & Freund's - Probability and Statistics for Engineers*, 8th Edition, PHI Learning, 2011.

P.T.O

Reference Books:

- R1. W. Mendenhall, R. J. Beaver, and B. M. Beaver, *Probability and Statistics*, 14th Edition, Cengage Learning, 2014.
- R2. R. E. Walpole, R. H. Myers, S. L. Myers, and K. E. Ye, *Probability & Statistics for Engineers & Scientists*, 9th Edition, PHI Learning, 2012.

Online Resources:

1. <https://nptel.ac.in/courses/111/105/111105041/>: by Prof. S. Kumar, IIT Kharagpur
2. <https://ocw.mit.edu/courses/mathematics/18-440-probability-and-random-variables-spring-2014/lecture-notes/>

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

| | |
|-----|---|
| CO1 | Apply the concepts of probability and random variables to evaluate probabilities of events. |
| CO2 | Apply different discrete and continuous probability models to solve real life problems. |
| CO3 | Apply the concepts of sampling to estimate population parameters and test hypothesis. |
| CO4 | Test the goodness of a model and apply it to real life problems. |
| CO5 | Apply regression model and ANOVA to study the characteristics data sets. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Data Structures & Algorithms | L-T-P | Credits | Marks |
|------|---------------|------------------------------|-------|---------|-------|
| ES | BTCS-T-ES-003 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | To understand the abstract data types and to solve problems using data structures such as stacks, queues, linked lists, hash tables, binary trees, heaps, binary search trees, graphs and writing programs for these solutions. |
| Pre-Requisites | Knowledge of programming in C, specifically on structures, pointers, functions, recursion etc., are required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Introduction to data structures, classification of data structures, algorithmic notation, complexity of algorithms, asymptotic notations, abstract data types. Arrays - introduction, representation of arrays (row and column major representation), basic operations on array (traverse, insert, delete, search), sparse matrix, representation of sparse matrix using triplet form, operations on sparse matrix (addition, transpose) | 8 Hours |
| Module-2 | ADT Stack - stack model, representation of stack using array, basic operations with analysis, applications- recursion, and conversion of infix to post fix expression, evaluation of postfix expression. ADT Queue - queue model, representation using array, basic operations with analysis, circular queue, introduction to priority queue and double ended queue. | 8 Hours |
| Module-3 | Linked list - introduction, types of linked list (single, double, circular), representation in memory, operations on linked list (traverse, search, insert, delete, sort, merge) in each type with analysis. Representation of polynomial and its operations (addition, multiplication), implementation of stack and queue using linked list. | 9 Hours |
| Module-4 | Tree - terminology, representation, binary tree - tree traversal algorithms with and without recursion. Binary search tree, Operations on Binary Search Tree with analysis, threaded binary tree, general tree, Height balanced tree (AVL tree), m-way search trees, B-trees. Graph - terminology, representation (adjacency matrix, incidence matrix, path matrix, linked representation), graph traversal (BFS, DFS), Dijkstra's single source shortest path algorithm, Warshall's all pair shortest path algorithm, topological sort. | 9 Hours |
| Module-5 | Sorting algorithms - bubble sort, selection sort, insertion sort, quick sort, merge sort, radix sort, heap sort. Hashing- hash functions and hashing techniques. collision resolution techniques- linear probing, quadratic probing, chaining. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. E. Horowitz, S. Sahni, S. Anderson-Freed, *Fundamentals of Data Structures in C*, 2nd Edition, Universities Press, 2008.
- T2. M. A. Weiss, *Data Structures and Algorithm Analysis in C*, 2nd Edition, Pearson Education, 2002.

Reference Books:

- R1. A. M. Tenenbaum, Y. Langsam, and M. J. Augenstein, *Data Structures Using C*, 3rd Edition, Pearson Education, 2007.
- R2. J. P. Tremblay and P. G. Sorenson, *An Introduction to Data Structures with Applications*, 2nd Edition, McGraw Education, 2017.
- R3. S. Lipschutz, *Data Structures*, 1st Revised Edition, McGraw Education, 2014.

Online Resources:

1. <https://nptel.ac.in/courses/106/106/106106127/>: By Prof. H. A. Murthy, Prof. S. Balachandran, and Dr. N. S. Narayanaswamy, IIT Madras
2. <https://nptel.ac.in/courses/106/102/106102064/>: By Prof. N. Garg, IIT Delhi
3. <https://nptel.ac.in/courses/106/106/106106130/>: By Dr. N. S. Narayanaswamy, IIT Madras
4. <https://www.geeksforgeeks.org/data-structures/>

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

| | |
|-----|--|
| CO1 | Analyze performance of algorithms and implement various operations on array and sparse matrix. |
| CO2 | Apply the basic operations of stacks and queues to solve real world problems. |
| CO3 | Implement different types of linked list operations and their applications. |
| CO4 | Represent data using trees & graphs to use them in various real life applications. |
| CO5 | Analyze various sorting algorithms and explore different hashing techniques. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO6 | 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. |
| PO12 | 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. |

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Communicative & Technical English | L-T-P | Credits | Marks |
|------|---------------|-----------------------------------|-------|---------|-------|
| HS | BTBS-T-HS-099 | | 2-0-0 | 2 | 100 |

| | |
|------------------------|---|
| Objectives | The objectives of this course are to develop the students' communication skills with proficiency in Technical English, make them speak with a standard accent, develop analytical skills to read and comprehend texts, and help students compose basic business messages. |
| Pre-Requisites | Basic knowledge of English grammar and the ability to read and write using the English language. |
| Teaching Scheme | Regular classroom lectures with the use of PPTs as and when required; sessions are planned to be interactive with focus on improving spoken and written communication skills in English. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Elements of Communication: Process, factors and importance of communication; Principles of communication; Barriers to communication; General vs Business communication. | 3 Hours |
| Module-2 | Sounds of English: Importance of neutral accent; vowels, diphthongs, consonants and consonant clusters; syllable and stress. | 5 Hours |
| Module-3 | Critical Reading: Importance of reading; Intensive and extensive reading; reading strategies, Reading texts (short story, contemporary essay, editorial). | 5 Hours |
| Module-4 | Effective Business Communication (Oral): Purpose and importance of business communication; technology in communication; Structure of business organisation; Patterns of business communication; Models of communication in business settings. | 7 Hours |
| Module-5 | Effective Business Communication (Written): Constituents of effective business writing; Process writing; Paragraph writing; Common written forms in business writing; Importance, features, format and uses. | 8 Hours |
| Total | | 28 Hours |

Text Books:

- T1. M. A. Rizvi, *Effective Technical Communication*, 2nd Edition, McGraw-Hill Education, 2017.
- T2. T. Balasubramaniam, *English Phonetics for Indian Students*, 3rd Edition, Trinity Press, 2017.
- T3. M. Raman and S. Sharma, *Technical Communication: Principles & Practice*, 2nd Edition, Oxford University Press, 2011.
- T4. D. K. Das, A. Kumari, and K. K. Padhi, *Anthology of Modern English Prose*, 1st Edition, Laxmi Publications, 2011.

Reference Books:

- R1. S. Kumar and P. Lata, *Communication Skills*, Oxford University Press, 2011.
- R2. K. R. Lakshminarayanan and T. Murugavel, *Communication Skills for Engineers*, Scitech Publications, 2009.

- R3. J. Seeley, *The Oxford Guide to Effective Writing and Speaking*, 3rd Edition, Oxford University Press, 2013.
- R4. B. K. Das, K. Samantray, R. Nayak, S. Pani, and S. Mohanty, *An Introduction to Professional English and Soft Skills*, Cambridge University Press, 2009.
- R5. S. Samantray, *Business Communication and Communicative English*, S. Chand & Co, 2017.

Online Resources:

1. <https://nptel.ac.in/courses/109/106/109106094/>: By Prof. A. Iqbal, IIT Madras
2. <https://nptel.ac.in/courses/109/104/109104031/>: By Dr. T. Ravichandran, IIT Kanpur
3. <https://www.coursera.org/specializations/business-english>
4. <https://ocw.mit.edu/courses/comparative-media-studies-writing/21w-732-5-introduction-to-technical-communication-explorations-in-scientific-and-technical-writing-fall-2006/download-course-materials/>

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

| | |
|-----|---|
| CO1 | Understand the elements of and technical communication and possible barriers to it. |
| CO2 | Explain the basic aspects of English pronunciation and speak using a neutral accent. |
| CO3 | Enhance their reading skills and be able to critically analyse texts of various kinds. |
| CO4 | Effectively use the channels of business communication and hierarchies to communicate in a business set-up. |
| CO5 | Compose basic business correspondences effectively. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| PO9 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO10 | 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. |
| PO11 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Engineering Chemistry Lab | L-T-P | Credits | Marks |
|------|---------------|---------------------------|-------|---------|-------|
| BS | BTBS-P-BS-003 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|---|
| Objectives | Objectives of the subject is to educate the students with modern instrumental techniques & role of chemical analysis in various fields of engineering and science to examine and understand the effect of chemicals, compositions, impurities etc., on the properties of materials & the detrimental effects of polluting materials, and other unwanted impurities. |
| Pre-Requisites | Student should have the knowledge of balancing equations, principle of titrations, titrant, titrand, preparation of standard solutions, concentration of a solution, indicators used in a titration, principle of reduction-oxidation reactions, handling of instruments like pH meter & accurate measurement of sample by using electronic balance. |
| Teaching Scheme | Regular laboratory experiments conducted under supervision of the teacher. Demonstration will be given for each experiment. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|---------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------------------------|---|
| <i>At least 10 Experiments</i> | |
| 1 | Determination of Total hardness of water sample by EDTA method. |
| 2 | Determination of alkalinity of water. |
| 3 | Determination of available chlorine of bleaching powder/residual chlorine in tap water. |
| 4 | Determination of dissolved oxygen in supplied water. |
| 5 | Determination of saponification value of oil. |
| 6 | Determination of Acid value of oil. |
| 7 | Determination of Flash-point/fire point of a lubricant by Pensky-Martens apparatus. |
| 8 | Determination of kinematic viscosity and Viscosity Index of a lubricant by Redwood viscometer. |
| 9 | Determination of concentration of a colour substance by Spectrophotometer. |
| 10 | Green synthesis of noble metal/oxide based nanoparticles. |
| 11 | Estimation of calcium in limestone powder. |
| 12 | Determination of chloride content of water. |
| 13 | Determination of the partition coefficient of a substance between two immiscible liquids. |
| 14 | Adsorption of acetic acid by charcoal. |
| 15 | Use of the capillary viscosimeters to demonstrate the isoelectric point as the pH of minimum viscosity for gelatin solutions and/or coagulation of the white part of egg. |

Cont'd...

| Experiment-# | Assignment/Experiment |
|--------------|---|
| 16 | Proximate analysis of coal sample. |
| 17 | Determination of iodine value of oil / fat. |

Text Books:

- T1. Jain & Jain, *Engineering Chemistry*, 16th Edition, Dhanpat Rai Publishing Company, 2015.
 T2. S. S. Dara, *Engineering Chemistry*, 12th Edition, S. Chand Publisher, 2014.

Reference Books:

- R1. S. Chawla, *Essentials of Experimental Engineering Chemistry*, Dhanpat Rai & Co.
 R2. S. K. Bhasin and S. Rani, *Laboratory Manual on Engineering Chemistry*, 3rd Edition, Dhanpat Rai & Co, 2012.

Online Resources:

- <https://www.metrohm.com/en/industries/petro-lubricants/>: Lubricant analysis according to international standards
- <http://www.eco-web.com/edi/01759.html>: Efficient Wastewater Treatment: The field for analytical and monitoring

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

| | |
|-----|--|
| CO1 | Analyse various water quality parameters such as alkalinity, hardness, dissolved oxygen & chloride content before it is put into use in various general, research, or industrial purposes. |
| CO2 | Test the quality of an oil/fat by measuring its iodine or acid value by means of amount of unsaturation for various industrial use. |
| CO3 | Verify quality of a lubricant by means of its viscosity or flash point which gives their nature & flammability for various industrial applications. |
| CO4 | Analyse various fractions present in coal by proximate analysis for better use of carbon based compounds in industrial applications. |
| CO5 | Study the importance of green synthesis by way of synthesising metal/ metal oxide based nano-particles for various material applications. |

Program Outcomes Relevant to the Course:

| | |
|-----|---|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO7 | 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. |

Cont'd...

| | |
|------|--|
| PO9 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO10 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Engineering Physics Lab | L-T-P | Credits | Marks |
|------|---------------|-------------------------|-------|---------|-------|
| BS | BTBS-P-BS-007 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to develop the basic practical skill to design and measure different parameters of a physical quantity with proper error analysis which can help them in different field of engineering sciences. This practical knowledge will be useful for the engineering students to understand the basic operating principle of instruments. The knowledge obtained can also be used to prepare various models and projects. |
| Pre-Requisites | Adequate practical knowledge in Higher Secondary Physics including measuring instruments like screw gauge, slide caliper, spherometer etc. Knowledge of error analysis, graphical analysis etc. is also required. |
| Teaching Scheme | Regular laboratory experiments conducted under supervision of the teacher. Demonstration will be given for each experiment. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|--|
| 1 | Determination of bandgap of semiconductor. |
| 2 | Determination of rigidity modulus by static method. |
| 3 | Determination of surface tension by capillary rise method. |
| 4 | Determination of acceleration due to gravity by bar / Kater's pendulum. |
| 5 | Determination of Plank's constant, verification of inverse square law by photocell. |
| 6 | Determination of wavelength of light by Newton's ring apparatus. |
| 7 | Determination of grating element of a diffraction grating. |
| 8 | Plotting of characteristic curve of a PN junction diode. |
| 9 | Plotting of characteristic curves of BJT. |
| 10 | Verification of laws of vibration of stretched string using sonometer. |
| 11 | Determination of wavelength of laser source by diffraction grating method. |
| 12 | Study of Hall effect. |
| 13 | Study of RC circuit. |
| 14 | Determination of Young's modulus by bending of beams. |
| 15 | Michelson Interferometer. |
| 16 | Determine of reduction factor of the given tangent galvanometer and horizontal component of Earth's magnetic field using tangent galvanometer. |

Text Books:

- T1. C. L. Arora, *B.Sc. Practical Physics*, 20th Edition, S.Chand & Co.Ltd, 2009.
 T2. S. Srivastava, *Practical Physics*, 3rd Edition, New Age International, 2017.

Reference Books:

- R1. H. Singh, *B.Sc. Practical Physics*, S. Chand & Co.Ltd, 2002.
 R2. B.Mallick, S. Panigrahi, *Engineering Practical Physics*, Cengage Learning, 2015.

Online Resources:

1. <https://nptel.ac.in/courses/122103010/>
2. <https://www.practicalphysics.org/>
3. <http://www.bsauniv.ac.in/>: Search for PHYSICS-LAB-MANUAL2017-(new-regulation).pdf
4. <https://arxiv.org/ftp/arxiv/papers/1510/1510.00032.pdf>

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

| | |
|-----|--|
| CO1 | Analyze the wave aspect of light like interference and diffraction by conducting Newton's rings and Fraunhofer diffraction experiment. |
| CO2 | Investigate some properties of matter like surface tension of water (capillary rise method) and coefficient of elasticity of steel, copper. |
| CO3 | Verify and analyze the IV characteristics of junction diode and BJT, charging and discharging of capacitor in RC circuit. |
| CO4 | Study and apply Hall effect to calculate the Hall coefficient, carrier concentrations; measure band gap of semiconductor and dielectric constant of dielectric material. |
| CO5 | Understand and verify laws of transverse vibrations in a stretched string using sonometer. |

Program Outcomes Relevant to the Course:

| | |
|------|---|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Manufacturing Practices | L-T-P | Credits | Marks |
|------|---------------|-------------------------|-------|---------|-------|
| ES | BTBS-P-ES-009 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this practical course is to provide the basic concepts about tools used in manufacturing practices. Detailed concepts are proposed in all the major trades of engineering interest. |
| Pre-Requisites | None |
| Teaching Scheme | Regular manufacturing jobs using tools under supervision of the teacher. Demonstration will be given for each experiment. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|---------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|--|
| 1 | Introduction & familiarity with tools: measuring, marking, holding, and cutting tools, Fitting (limit, fit, tolerance), Fastening (different types of screws, rivets, nuts & bolts). |
| 2 | Welding: Arc welding & Gas welding - theory & setup, Machining: Study of different parts & function of Lathe, Milling & Shaping. |
| 3 | To make a hexagonal bolt & nut with facing, step turning, internal & external threading & grooving (V-groove, rectangular groove on a square block) using Lathe, milling & shaping machine. |
| 4 | To make a flange coupling using Gas welding, arc welding & fitting. |
| 5 | To make heat-sink by using a metal plate (sheet metal work). |
| 6 | Introduction to electrical tools and safety measures. Demonstrate the precautionary steps adopted in case of electrical shocks. |
| 7 | Identify different types of cables, wires, switches, fuses, fuse carriers, MCB, ELCB and MCCB with ratings. |
| 8 | To design and develop a simple winding for inductor and 230/12V transformers used in electronics circuits. |
| 9 | Introduction to house wiring: <ol style="list-style-type: none"> 1. Wiring of simple circuit for controlling light/fan point. 2. Wiring of Two-way switches. 3. Wiring of power distribution arrangement using single phase MCB distribution board with ELCB, main switch and Energy meter. |
| 10 | Familiarization of PCB assembling tools [such as Soldering iron, Desoldering pump, Pliers, Cutters, Wire strippers, Screwdrivers, Tweezers, Crimping tool, Micro-soldering station, Hot air soldering and de-soldering station etc.] and testing tools [such as Multimeter, DSO, clamp meter, function generator etc.] |
| 11 | Familiarization of EDA tools (such as Eagle or Xcircuit) with general purpose components for designing a Printed Circuit Board (PCB) and fabrication of a single sided PCB for a simple circuit with manual etching (Ferric chloride solution). |
| 12 | Testing of a sample PCB (Types: Single sided, Double sided) for selected applications with general purpose instruments. |

Text Books:

- T1. S. K. H. Choudhury, *Elements of Workshop Technology, Vol-1 and Vol-2*, Media Promotors & Publishers, 2008.
- T2. B. H. Deshmukh, *Electrical Materials and Wiring Practices*, Nirali Prakashan, 2018.
- T3. R. S. Khandpur, *Printed Circuit Boards: Design, Fabrication, Assembly and Testing*, 1st Edition, McGraw Hill, 2006.

Reference Books:

- R1. S. Monk, *Make Your Own PCBs with EAGLE: From Schematic Designs to Finished Boards*, McGraw-Hills, 1st edition, 2014.
- R2. H. Joshi, *Residential, Commercial and Industrial Electrical Systems: Protection, Testing and Commissioning, Vol-3*, McGraw-Hill Education, 2008.
- R3. J. Varterisian, *Fabricating Printed Circuit Boards*, 1st Edition, Newnes, 2002.

Online Resources:

1. <http://www.technicaltrainingsolutions.co.uk/courses/bench-fitting-course.html>
2. <http://nptel.ac.in/courses/112101005/14>: (Sheet Metal Forming Processes)
3. <http://nptel.ac.in/downloads/112105127>: (Machining Processes)
4. <http://nptel.ac.in/courses/112107144/27>: (Welding Processes)
5. https://bharatskills.gov.in/pdf/E_Books/Electrician_SEM1_TP.pdf
6. https://bharatskills.gov.in/pdf/E_Books/Electrician_SEM2_TP.pdf
7. <https://bharatskills.gov.in/Home/StudyMaterial?var=WSdYV6aWadK8jUuNKxoBWg==>
8. https://onlinecourses.swayam2.ac.in/nou20_cs08/preview
9. https://www.lanl.gov/safety/electrical/docs/arc_flash_safety.pdf
10. https://www.ee.iitb.ac.in/~pcpandey/courses/ee616/pcblayout.c_aug07.pdf
11. <https://nptel.ac.in/courses/108/108/108108157/>
12. <https://nptel.ac.in/courses/122/106/122106025/>
13. <https://nptel.ac.in/courses/108/101/108101091/>

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

| | |
|-----|--|
| CO1 | Brief idea about the workshop, different tools and their operation, limits, fits, tolerance while assembling different parts of a flange coupling by using fitting shop. |
| CO2 | Design and fabricate the components of a flange coupling by using machine tools and welding operation. |
| CO3 | Identify different safety equipment and apply those in various electrical systems. |
| CO4 | Plan and Design wiring configuration of residential and office and calculate the energy consumption for various loads. |
| CO5 | Familiarity with PCB designing and fabrication methodology for different applications. |
| CO6 | Analysis and application of specific PCB using modern instruments. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |

Cont'd...

| | |
|------|--|
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| PO9 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO10 | 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. |
| PO11 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|
| CO1 | 2 | | 1 | 1 | | 2 | | | 3 | | 3 | 2 | 1 | 1 | 1 |
| CO2 | 2 | 1 | 2 | 1 | | 2 | | | 3 | | 3 | 2 | 1 | 1 | 1 |
| CO3 | 1 | 1 | 2 | 1 | 2 | 1 | | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 1 |
| CO4 | 2 | 3 | 3 | 1 | 1 | 1 | | 1 | 2 | 2 | 3 | 1 | 1 | 1 | 1 |
| CO5 | 3 | 3 | 3 | 1 | 2 | 1 | | | 3 | 1 | 3 | 2 | 2 | 3 | 2 |
| CO6 | 3 | 3 | 1 | 1 | 2 | 1 | | | 2 | 1 | 3 | 2 | 2 | 2 | 1 |

| Type | Code | Engineering Graphics | L-T-P | Credits | Marks |
|------|---------------|----------------------|-------|---------|-------|
| ES | BTBS-P-ES-004 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this laboratory course is to learn engineering drawing standards, conventions & practices, develop drawing skills in 2D & 3D, and use computer-aided drawing software to create meaningful engineering drawings. |
| Pre-Requisites | Basic understanding of 2D and 3D geometry is required. |
| Teaching Scheme | Regular laboratory classes using drawing tools under supervision of the teacher. Demonstration will be given for each drawing assignment using both conventional and CAD software tools as per requirement. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|--|
| 1 | Principles of Engineering Graphics and their significance (lettering & scale) and usage of Drawing instruments. |
| 2 | Orthographic projections, Principles of orthographic projections, Projections of points and lines. |
| 3 | Projections of different planes. |
| 4 | Projection of solids, 3D to 2D views, Machine component diagrams, Sectional views of simple and compound solid models. |
| 5 | Principles of Isometric projection, Isometric Scale & Views, Isometric views of planes and solids. |
| 6 | Development of surface and intersection of surfaces. |
| 7 | Engineering curves and conics. |
| 8 | Introduction to AutoCAD, GUI of AutoCAD, Tool bars and commands, use of mouse and short cut keys. |
| 9 | 2D AutoCAD drawing using basic tools, Draw & Modify menu commands. |
| 10 | Orthographic projection drawings of various models using AutoCAD. |
| 11 | Isometric drawing & 3D modeling in AutoCAD, different solid editing options. |
| 12 | 3D modeling of simple & compound models, and machine components using AutoCAD. |

Text Books:

- T1. N. D. Bhat, M. Panchal, *Engineering Drawing*, Charotar Publishing House, 2008.
- T2. M. B. Shah, B. C. Rana, *Engineering Drawing and Computer Graphics*, Pearson Education, 2008.
- T3. S. Tickoo, *AutoCAD 2020 Work Book*, BPB Publications, 2020.

Reference Books:

- R1. R. K. Dhawan, *A Text Book of Engineering Drawing*, S. Chand Publications, 2007.
- R2. K. Venugopal, *Engineering Drawing and Graphics*, 3rd Edition, New Age International, 1998.

Online Resources:

1. <http://nptel.ac.in/courses/112103019>
2. <https://nptel.ac.in/courses/112/102/112102101/>
3. <https://freevideolectures.com/course/3420/engineering-drawing>
4. <https://www.autodesk.in/campaigns/autocad-tutorials>
5. <https://help.autodesk.com/view/ACD/2020/ENU/>

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

| | |
|-----|---|
| CO1 | Understand and apply the concepts of lettering and dimensioning for drafting of machine drawings and building drawings and different conics and curves. |
| CO2 | Recognize and be familiar with the orthographic projections of points, lines, planes and solids. |
| CO3 | Visualize the real product from isometric projections, solid and sectional views. |
| CO4 | Become familiar with AutoCAD, its different tools and commands. |
| CO5 | Draw various 2D drawings using draw and modify tools of AutoCAD. |
| CO6 | Design various machine components and building structure by using AutoCAD. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO10 | 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. |
| PO11 | 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. |
| PO12 | 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. |

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Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|
| CO1 | 3 | 1 | 1 | 1 | 1 | | | | | 2 | 1 | 1 | 1 | | 1 |
| CO2 | 3 | 2 | 1 | 1 | 1 | | | | | 2 | 1 | 1 | 1 | | 1 |
| CO3 | 3 | 2 | 1 | 1 | 1 | | | | | 2 | 1 | 1 | 1 | | 1 |
| CO4 | 3 | 1 | 1 | 1 | 1 | | | | | 2 | 1 | 1 | 1 | | 1 |
| CO5 | 3 | 2 | 2 | 2 | 3 | | | | | 2 | 2 | 1 | 1 | | 1 |
| CO6 | 3 | 2 | 1 | 1 | 2 | | | | | 2 | 2 | 1 | 2 | | 2 |

| Type | Code | Basic Electronics Engineering Lab | L-T-P | Credits | Marks |
|------|---------------|-----------------------------------|-------|---------|-------|
| ES | BTEC-P-ES-002 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|---|
| Objectives | Know broadly the concepts and functionalities of the electronic devices, tools and instruments. Understand general specifications and deployability of the electronic devices, and assemblies. Develop confidence in handling and usage of electronic devices, tools and instruments in engineering applications. |
| Pre-Requisites | Knowledge on intrinsic and extrinsic Semiconductors, Physics and Chemistry of Higher Secondary Science level. |
| Teaching Scheme | Regular laboratory experiments to be conducted under the supervision of teachers and demonstrators with the help of ICT, as and when required along with pre-lab session and demonstration for each experiment. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|--|
| 1 | Familiarization of electronic components and devices (Testing of semiconductor diodes and transistors using digital multi-meter). |
| 2 | Study and use of Oscilloscope, signal generator to view waveforms and measure amplitude and frequency of a given waveform. |
| 3 | V-I characteristics of semiconductor diode and determining its DC and AC resistances. |
| 4 | Implementation of clipper circuits, both positive clipper and negative clipper. Observe its output waveforms and compare them with theoretical analyzed results. |
| 5 | Study of half-wave and full-wave rectifier circuits without and with capacitor filter; recording of the waveforms and measurement of average and rms values of the rectified output. |
| 6 | Study of static characteristics of BJT in CE configuration. |
| 7 | DC biasing (Fixed bias) of the transistor in CE configuration and determination of its operating point. |
| 8 | Studies on Op-Amp applications (Inverting, non-inverting, integrating differentiating configurations) recording of the input-output waveforms. |
| 9 | Studies on logic gates (truth table verification of various gates, implementation of EXNOR and Half Adder using basic gates). |
| 10 | Design of 2:1 MUX and simple SR Latch. |

Text Books:

- T1. R. L. Boylestad and L. Nashelsky, *Electronic Devices and Circuit Theory*, 11th Edition, Pearson Education.
- T2. A. S. Sedra and K. C. Smith, *Microelectronic Circuits*, 7th Edition, Oxford University Press.

Reference Books:

- R1. V. K. Mehta and R. Mehta, *Principles of Electronics*, 3rd Edition, S. Chand Publishing, 1980.

Online Resources:

1. http://vlab.co.in/ba_labs_all.php?id=1
2. <http://iitg.vlab.co.in/?sub=59&brch=165>

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

| | |
|-----|--|
| CO1 | Familiarize with various electronic components, measuring instruments, semiconductor diodes and their applications. |
| CO2 | Acquire knowledge of characteristics of transistors and design, testing & implementation of transistors in various applications |
| CO3 | Gain understanding of operational amplifiers (Op-Amp) and design & testing of electronic circuits for various applications using Op-Amp. |
| CO4 | Develop understanding of digital logic gates and design & test digital circuits for various applications using logic gates. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Basic Electrical Engineering Lab | L-T-P | Credits | Marks |
|------|---------------|----------------------------------|-------|---------|-------|
| ES | BTEE-P-ES-002 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|---|
| Objectives | Introduce the students to different electrical components and basic safety rules and regulations, give hands on practice about different measuring and protection equipment and their operations to understand and verify the basic concept of electrical & magnetic circuits and electric machines. The laboratory experiments shall go hand-in-hand with the topics taught in the theory class. |
| Pre-Requisites | Basic knowledge of different electrical components and different analysis techniques of electrical and magnetic circuits. Topics taught in Basic Electrical Engineering theory class are essential to conduct the experiments. |
| Teaching Scheme | Regular laboratory experiments conducted under supervision of the teacher. Demonstration will be given for each experiment. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|---------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|--|
| 1 | Connection and measurement of power consumption of a fluorescent lamp. |
| 2 | Identification of different terminals of a DC compound machine. |
| 3 | Power and power factor measurement of 3-phase load by two wattmeter method. |
| 4 | Connection and testing of a single-phase energy meter. |
| 5 | Determination of open circuit characteristics (OCC) of DC shunt generator. |
| 6 | Calculation of power and power factor in series R-L-C circuit by AVW method. |
| 7 | Polarity test of a single-phase transformer. |
| 8 | Study of single-phase induction motors / fan motor. |
| 9 | Verify Thevenin's Theorem and Superposition Theorem. |
| 10 | Draw the B-H curve of a magnetic Specimen. |
| 11 | Starting of three-phase induction motor. |
| 12 | Regulation and efficiency of single phase transformer by direct loading. |

Text Books:

- T1. A. Husain, *Fundamentals of Electrical Engineering*, 4th Edition, Dhanpat Rai & Co., 2016.
 T2. B. L. Thereja & A. K. Thereja, *A Textbook of Electrical Technology*, 23rd Edition, S. Chand & Co.

Reference Books:

- R1. J. B. Gupta, *A Textbook of Electrical Science*, S. K. Kataria & Sons, 2013.
 R2. B. R. Gupta and V. Singhal, *Electrical Science*, S. Chand & Co, 2005.

Online Resources:

1. www.nptel.iitm.ac.in/electricalengineering
2. www.electronics-tutorials.ws/dc-circuits

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

| | |
|-----|--|
| CO1 | Get an exposure to common electrical components and their ratings. |
| CO2 | Develop electrical circuits using wires, measuring instruments, and protective devices of appropriate ratings. |
| CO3 | Understand the usage of common electrical measuring instruments. |
| CO4 | Understand the basic characteristics of transformers and electrical machines. |
| CO5 | Verify different network theorems and magnetic properties. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO4 | 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. |
| PO6 | 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. |
| PO8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| PO9 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO10 | 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. |
| PO11 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Computer Programming Lab | L-T-P | Credits | Marks |
|------|---------------|--------------------------|-------|---------|-------|
| ES | BTCS-P-ES-002 | | 0-0-4 | 2 | 100 |

| | |
|------------------------|--|
| Objectives | To enable the students to analyse problems, formulate and implement solutions using the C programming language. The students will develop logical understanding for converting solutions of problems into C programs to be executed on a computer. |
| Pre-Requisites | Basic analytical and logical understanding including basic knowledge and usage of computers is required for this course. |
| Teaching Scheme | Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of programming assignments. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|---------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|---|
| 1 | Introduction to computers and Linux operating system. |
| 2, 3 | Get acquainted with the programming environment - Linux commands and VI-editor. |
| 4 | Editing, compiling, executing, and debugging of simple C programs. |
| 5 | Programs using operators and formatted input/output statements. |
| 6 | Decision making using if, if-else, else-if ladder, nested if. |
| 7 | Decision making using switch-case construct. |
| 8, 9 | Loop control structure (while, do-while, for) with jump statements. |
| 10 | Nested loops (printing various formats) |
| 11, 12 | 1-D arrays including operation like searching, sorting, merging etc. |
| 13 | Handling 2-D arrays such as matrix operations. |
| 14, 15 | Programs on strings using various string handling functions (library functions) |
| 16, 17 | Designing user-defined functions. |
| 18, 19 | Programs on recursion. |
| 20 | Designing user defined functions for string manipulation. |
| 21 | Passing arrays (both 1D and 2D) to functions. |
| 22, 23 | Structure, array of structure, nested structure. |
| 24 | Dynamic memory management. |
| 25 | Self-referential structure (create and display operation of single linked list) |
| 26, 27 | File handling - reading from and writing to files. |
| 28 | Command-line argument, pre-processor directives. |

Text Books:

- T1. E. Balagurusamy, *Programming in ANSI C*, 7th Edition, McGraw-Hill Education, 2017.
- T2. Y. Kanetkar, *Let Us C*, 16th Edition, BPB Publications, 2018.

Reference Books:

- R1. B. W. Kernighan and D. M. Ritchie, *The C Programming Language*, 2nd Edition, Pearson Education, 2015.
- R2. H. Schildt, *C: The Complete Reference*, 4th Edition, McGraw-Hill, 2017.
- R3. A. Kelley and I. Pohl, *A Book on C*, 4th Edition, Pearson Education, 2008.
- R4. B. Gottfried, *Schaum's Outline of Programming with C*, 3rd Edition, McGraw-Hill, 2017.

Online Resources:

1. <https://www.w3resource.com/c-programming-exercises/>
2. <https://www.includehelp.com/c-programming-examples-solved-c-programs.aspx>
3. https://www.onlinegdb.com/online_c_compiler
4. https://www.tutorialspoint.com/compile_c_online.php

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

| | |
|-----|--|
| CO1 | Construct C programs for mathematical operations using control statements. |
| CO2 | Develop C programs for Array and String manipulation. |
| CO3 | Construct modular programs for better maintenance and reusability. |
| CO4 | Manipulate heterogeneous data using structure and union. |
| CO5 | Create and manipulate files using C programs. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Data Structures & Algorithms Lab | L-T-P | Credits | Marks |
|------|---------------|----------------------------------|-------|---------|-------|
| ES | BTCS-P-ES-004 | | 0-0-4 | 2 | 100 |

| | |
|------------------------|--|
| Objectives | Develop skills to design and analyze simple linear and non linear data structures, strengthening the ability of students to identify and apply the suitable data structure for the given real world problem. |
| Pre-Requisites | Knowledge of programming in C, specifically on structures, pointers, functions, recursion etc., are required. |
| Teaching Scheme | Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of programming assignments. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|---|
| 1 | Operations on arrays – insert, delete, merge. |
| 2 | Selection Sort, Bubble sort. |
| 3 | Linear Search and Binary search. |
| 4 | Representation of sparse matrix. |
| 5, 6 | Addition and transpose of sparse matrix. |
| 7 | Implementation of stack using array. |
| 8 | Conversion of infix to postfix expression. |
| 9 | Evaluation of postfix expression. |
| 10 | Operations of queue using array. |
| 11 | Operations of circular queue. |
| 12, 13 | Single linked list operations. |
| 14, 15 | Double linked list operations. |
| 16 | Circular linked list operations. |
| 17 | Stack using linked list. |
| 18 | Queue using linked list. |
| 19 | Polynomial addition using linked-list. |
| 20, 21 | Binary Search Tree operations. |
| 22, 23 | Graph traversal (BFS, DFS). |
| 24 | Warshall's shortest path algorithm. |
| 25, 26 | Implementation Insertion Sort and Quick Sort. |
| 27, 28 | Implementation of Merge Sort and Heap Sort. |

Text Books:

- T1. E. Horowitz, S. Sahni, S. Anderson-Freed, *Fundamentals of Data Structures in C*, 2nd Edition, Universities Press, 2008.
- T2. M. A. Weiss, *Data Structures and Algorithm Analysis in C*, 2nd Edition, Pearson Education, 2002.

Reference Books:

- R1. A. K. Rath and A. K. Jagadev, *Data Structures Using C*, 2nd Edition, Scitech Publication, 2011.
 R2. Y. Kanetkar, *Data Structures Through C*, 2nd Edition, BPB Publication, 2003.

Online Resources:

1. <https://nptel.ac.in/courses/106/106/106106127/>: By Prof. H. A. Murthy, Prof. S. Balachandran, and Dr. N. S. Narayanaswamy, IIT Madras
2. <https://nptel.ac.in/courses/106/102/106102064/>: By Prof. N. Garg, IIT Delhi
3. <https://nptel.ac.in/courses/106/106/106106130/>: By Dr. N. S. Narayanaswamy, IIT Madras

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

| | |
|-----|--|
| CO1 | Implement various operations on array and sparse matrix. |
| CO2 | Design functions to implement basic operations on stack & queue and apply them to solve real world problems. |
| CO3 | Implement single, double & circular linked list and apply them in various real life applications. |
| CO4 | Construct binary search tree and perform traversal, insertion, deletion, and search operations on it. |
| CO5 | Perform BFS and DFS traversal operations in a graph and implement various sorting and searching algorithms. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Communicative & Technical English Lab | L-T-P | Credits | Marks |
|------|---------------|---------------------------------------|-------|---------|-------|
| HS | BTBS-P-HS-011 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|--|
| Objectives | This laboratory course is designed to make students effective communicators and addressing issues like speaking inhibitions, accomplished by individual and team activities based on the four skills of language (LSRW). |
| Pre-Requisites | Basic knowledge of English grammar and the ability to speak, read and write using the English language. |
| Teaching Scheme | Regular laboratory classes with various tasks designed to facilitate communication through pair work, group/team work, individual and group presentations, discussions, role plays, listening to audios, watching videos, business writing and vocabulary enhancement. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|---|
| 1 | Module 1: Analyzing communication situations through role-plays. |
| 2 | Module 1: Barriers in communication: video analysis |
| 3 | Module 2: Developing pronunciation skills – speech sounds and stress |
| 4 | Module 2: Developing pronunciation skills: listening to native English speech |
| 5 | Module 3: Reading comprehension – extensive: short story |
| 6 | Module 3: Reading comprehension – intensive: editorial |
| 7 | Module 4: Models of oral business communication: role-plays |
| 8 | Module 4: Oral presentations |
| 9 | Module 4: Oral presentations |
| 10 | Module 4: Oral presentations |
| 11 | Module 5: Written Communication – paragraph development |
| 12 | Module 5: Business Writing – email |
| 13 | Module 5: Business Writing – letter |

Text Books:

- T1. M. A. Rizvi, *Effective Technical Communication*, 2nd Edition, Tata McGraw Hill, 2017.
- T2. T. Balasubramaniam, *English Phonetics for Indian Students*, Trinity Press.
- T3. M. Raman and S. Sharma, *Technical Communication: Principles and Practices*, Oxford University Press.

Reference Books:

- R1. S. Samantray, *Business Communication and Communicative English*, S. Chand & Co.
- R2. J. Seeley, *The Oxford Guide to Writing and Speaking*, Oxford University Press.
- R3. B. K. Mitra, *Communication Skills for Engineers*, Oxford University Press, 2011.
- R4. B. K. Das, *An Introduction to Professional English & Soft Skills*, Cambridge Univ. Press, 2009.

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

| | |
|-----|---|
| CO1 | Speak in public and overcome their inhibitions to speak. |
| CO2 | Develop English pronunciation skills through practice. |
| CO3 | Comprehend and critically appreciate technical texts. |
| CO4 | Work effectively as a member of a team or as a leader through group presentation assignments. |
| CO5 | Critically analyse texts of various kinds and compose effective business messages. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| PO9 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO10 | 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. |
| PO11 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

Part II

2nd Year B. Tech. (ECE)

Curriculum Structure

| Semester III | | | | | | | | |
|--------------|---------------|---|--------------|---|---|------------------|---|---|
| Type | Code | Course Title | WCH L-T-P | | | Credits L-T-P | | |
| THEORY | | | | | | | | |
| BS | BTBS-T-BS-041 | Mathematics-III for Electrical Sciences | 3 | 0 | 0 | 3 | 0 | 0 |
| ES | BTCS-T-ES-005 | OOP Using Java | 3 | 0 | 0 | 3 | 0 | 0 |
| PC | BTEE-T-PC-003 | Circuit Theory | 3 | 0 | 0 | 3 | 0 | 0 |
| PC | BTEC-T-PC-010 | Digital Electronic Circuits | 3 | 0 | 0 | 3 | 0 | 0 |
| PC | BTEI-T-PC-001 | Analog Electronic Circuits | 3 | 0 | 0 | 3 | 0 | 0 |
| PC | BTEC-T-PC-007 | Signal & Systems | 3 | 0 | 0 | 3 | 0 | 0 |
| PRACTICAL | | | | | | | | |
| ES | BTCS-P-ES-006 | OOP Using Java Lab | 0 | 0 | 2 | 0 | 0 | 1 |
| PC | BTEE-P-PC-004 | Circuit Theory Lab | 0 | 0 | 2 | 0 | 0 | 1 |
| PC | BTEC-P-PC-011 | Digital Electronic Circuits Lab | 0 | 0 | 2 | 0 | 0 | 1 |
| PC | BTEI-P-PC-002 | Analog Electronic Circuits Lab | 0 | 0 | 2 | 0 | 0 | 1 |
| PJ | BTII-P-PJ-001 | Summer Internship - I | 0 | 0 | 0 | 0 | 0 | 1 |
| | | SUB-TOTAL | 18 | 0 | 8 | 18 | 0 | 5 |
| | | TOTAL | 26 | | | 23 | | |

| Semester IV | | | | | | | | |
|-------------|---------------|--|--------------|---|---|------------------|---|---|
| Type | Code | Course Title | WCH L-T-P | | | Credits L-T-P | | |
| THEORY | | | | | | | | |
| BS | BTBS-T-BS-025 | Mathematics-IV for Electrical Sciences | 3 | 0 | 0 | 3 | 0 | 0 |
| ES | BTBS-T-ES-013 | Basics of Mechanical Engineering | 3 | 1 | 0 | 3 | 1 | 0 |
| PC | BTEC-T-PC-017 | Digital Signal Processing | 3 | 0 | 0 | 3 | 0 | 0 |
| PC | BTEC-T-PC-008 | Analog Communication | 3 | 0 | 0 | 3 | 0 | 0 |
| PC | BTEE-T-PC-005 | Control Systems Engineering | 3 | 0 | 0 | 3 | 0 | 0 |
| OE | | Open Elective - I | 3 | 0 | 0 | 3 | 0 | 0 |
| MC | BTBS-T-MC-020 | Universal Human Values & Professional Ethics | 2 | 0 | 0 | 0 | 0 | 0 |
| PRACTICAL | | | | | | | | |
| PC | BTEC-P-PC-018 | Digital Signal Processing Lab | 0 | 0 | 2 | 0 | 0 | 1 |
| PC | BTEC-P-PC-009 | Analog Communication Lab | 0 | 0 | 2 | 0 | 0 | 1 |
| PC | BTEE-P-PC-006 | Control Systems Engineering Lab | 0 | 0 | 2 | 0 | 0 | 1 |
| PC | BTBS-P-HS-012 | Corporate Communication Lab | 0 | 0 | 2 | 0 | 0 | 1 |
| | | SUB-TOTAL | 20 | 1 | 8 | 18 | 1 | 4 |
| | | TOTAL | 29 | | | 23 | | |

Note: Courses offered under each elective are given in "List of Electives" on Page 54.

List of Electives

| Code | Elective # and Subjects |
|--------------------------|--|
| <i>Open Elective - I</i> | |
| BTEE-T-OE-032 | [EEE] Basics of Power Systems |
| BTBS-T-OE-027 | [BSH] Applied Linear Algebra |
| BTBS-T-OE-028 | [BSH] Fluid Mechanics |
| BTCS-T-OE-036 | [CSE] Operating Systems |
| BTCS-T-OE-039 | [CSE] Programming in Python |
| BTEI-T-OE-020 | [EIE] Biomedical Instrumentation & Signal Processing |

Note: *Open Electives* are choice-based courses offered by other departments as indicated within brackets.

| Type | Code | Mathematics-III for Electrical Sciences | L-T-P | Credits | Marks |
|------|---------------|---|-------|---------|-------|
| BS | BTBS-T-BS-041 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to provide the knowledge of Fourier Transforms, analytic functions, poles & zeros, residue calculus, and Laplace transform for study of electrical sciences. |
| Pre-Requisites | Knowledge of calculus of single variable, coordinate geometry of two and three dimensions, matrix algebra, and ordinary differential equations is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Basics of Complex Numbers, Derivatives, Analytic Functions, C-R Equations, Basic elementary Complex functions. | 8 Hours |
| Module-2 | Complex Line Integration, Integral Theorems, Complex Power Series and Taylor Series. | 8 Hours |
| Module-3 | Laurent Series, Residue Integration and its application for evaluation of real integrals. | 8 Hours |
| Module-4 | Periodic function and Fourier series, Euler formula, Even and odd functions, Half range expansions, Fourier integrals, Power series solutions to ordinary differential equations. | 9 Hours |
| Module-5 | Laplace transform, inverse Laplace transform, shifting theorems, transform of derivatives and integrals, unit step function and Dirac delta function, applications to derivatives, differentiation and integration of transforms. | 9 Hours |
| Total | | 42 Hours |

Text Books:

T1. E. Kreyszig, *Advanced Engineering Mathematics*, 8th Edition, Wiley India, 2015.

Reference Books:

- R1. S. Pal and S. C. Bhunia, *Engineering Mathematics*, 1st Edition, Oxford University Press, 2015.
 R2. B. V. Ramana, *Higher Engineering Mathematics*, 1st Edition, McGraw-Hill, 2017.

Online Resources:

1. <http://www.nptel.ac.in/courses/111105035>
2. <http://www.nptel.ac.in/courses/122104017>
3. <http://nptel.ac.in/courses/122102009>
4. <http://nptel.ac.in/courses/111107063>
5. <https://www.coursera.org/learn/linearalgebra2>
6. <https://www.coursera.org/learn/differentiation-calculus>
7. <https://www.coursera.org/learn/single-variable-calculus>
8. <https://alison.com/courses/Algebra-Functions-Expressions-and-Equations>

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

| | |
|-----|--|
| CO1 | Understand the concepts of Analytic functions. |
| CO2 | Evaluate complex line integral and find the Taylor's series expansion of analytic functions. |
| CO3 | Expand functions in Laurent's Series and evaluate integrations using residues. |
| CO4 | Find the Fourier series and Fourier integral of functions. |
| CO5 | Apply the concept of Laplace transforms to solve ordinary differential equations. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | OOP Using Java | L-T-P | Credits | Marks |
|------|---------------|----------------|-------|---------|-------|
| ES | BTCS-T-ES-005 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to introduce the key concepts of object-oriented programming (OOP) using Java as the programming language. |
| Pre-Requisites | Basic analytical and logical understanding including basic knowledge and usage of computers is required for this course. Prior experience with a programming language will be beneficial. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Object oriented concepts: Object oriented systems development life cycle; Java Overview: Java Virtual Machine, Java buzz words, Data types, Operators, Control statements, Class fundamentals, Objects, Methods, Constructors, Overloading, Access modifiers. | 8 Hours |
| Module-2 | Inheritance: Basics of Inheritance, using super and final keyword, method overriding, Abstract classes, defining and importing packages, access protection, interfaces; | 8 Hours |
| Module-3 | Exception handling: Exception fundamentals, types, understanding different keywords (try, catch, finally, throw, throws), User defined exception handling; Threads: thread model, use of Thread class and Runnable interface, thread synchronization, multithreading, inter thread communication. | 9 Hours |
| Module-4 | Input/Output: Files, stream classes, reading console input; String manipulation: Basics of String handling, String class, StringBuilder, StringBuffer, StringTokenizer; Collection overview, Collection interfaces, Collection classes - ArrayList, LinkedList, Set, Tree; Accessing a collection using iterator & for-each statement. | 8 Hours |
| Module-5 | Introduction to GUI Programming: working with windows, frames, graphics, color, and font. AWT Control fundamentals; Event handling: Delegation event model, event classes, sources, listeners, Adapter class, Swing overview. | 9 Hours |
| Total | | 42 Hours |

Text Books:

- T1. H. Schildt, *Java: The Complete Reference*, 10th Edition, McGraw-Hill, 2017.
- T2. Y. D. Liang, *Introduction to Java Programming*, 9th Edition, Pearson Education, 2012.

Reference Books:

- R1. B. Bates, K. Sierra, *Head First Java*, 2nd Edition, O'Reilly Media, 2005.
- R2. E. Balaguruswamy, *Programming with Java - A Primer*, 4th Edition, McGraw-Hill, 2009.
- R3. T. Budd, *An Introduction to Object-Oriented Programming*, 3rd Edition, Pearson Education, 2009.

R4. I. Horton, *Beginning Java*, 7th Edition, Wrox Publications, 2011.

Online Resources:

1. <https://nptel.ac.in/courses/106105191/>
2. <https://docs.oracle.com/javase/tutorial/>
3. <http://www.javatpoint.com/java-tutorial>
4. <http://www.w3schools.in/java/>
5. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-00-introduction-to-computer-science-and-programming-fall-2008/video-lectures/lecture-14/>

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

| | |
|-----|---|
| CO1 | Apply object oriented principles to develop Java programs for real life applications. |
| CO2 | Employ inheritance techniques for developing reusable software. |
| CO3 | Develop robust & concurrent programs using exception handling and multi-threading. |
| CO4 | Design programs using I/O operations, string classes, and collection framework. |
| CO5 | Design GUI applications using AWT and Swing. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO6 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Circuit Theory | L-T-P | Credits | Marks |
|------|---------------|----------------|-------|---------|-------|
| PC | BTEE-T-PC-003 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is that the student should be able to analyze any circuit configuration, synthesize circuits with any given specifications or network functions, test and improve the design as required. |
| Pre-Requisites | Basics of Circuit analysis, Laplace transform, Fourier transform and Differential equations are required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Network Theorems: Thevenin's theorem, Norton's theorem, Superposition theorem, Reciprocity theorem, Maximum power transfer theorem; Coupled Circuits: Introduction to coupled Circuit, Dot Convention, coefficient of coupling, Electrical equivalent of magnetically coupled coils, Series and parallel connection of coupled coils. Transformer as a magnetically coupled circuit; Resonance: Introduction, Series Resonance, Parallel Resonance, Quality factor, Bandwidth and Selectivity for series resonant and parallel resonant circuits, Frequency Response Curve. | 11 Hours |
| Module-2 | Fundamentals of Laplace & Inverse Laplace Transform, initial and final value theorem; Application Of Laplace Transform to Transient Analysis: Response of RL, RC & RLC network with step, sinusoidal, impulse and ramp input. | 8 Hours |
| Module-3 | Periodic and Aperiodic functions, Fourier Series Analysis of Continuous Time Signals, Fourier Transform, Properties, Circuit analysis with Fourier Series and Fourier Transform, Circuit analysis with Fourier Transform, Introduction to Filters, Frequency Response Curve. | 7 Hours |
| Module-4 | Two Port Network Functions & Responses: Introduction, z, y, ABCD and h-parameters, Reciprocity and Symmetry, Interrelation of two-port parameters, Interconnection of two-port networks; Network Functions & Response: Transfer function and driving point function for one & two port networks, Concept of poles and zeros, Significance & Restriction on location of Poles and Zeros, Time domain behaviour from Pole-Zero plots. | 9 Hours |
| Module-5 | Network Synthesis: Hurwitz polynomial and its Properties, Positive real functions and their properties, Concepts of network synthesis, Realization of simple R-L, R-C and L-C functions in Cauer-I, Cauer-II, Foster-I and Foster-II forms. Filter Transfer functions and cut off frequencies. | 7 Hours |
| Total | | 42 Hours |

Text Books:

T1. M. E. Van Valkenburg, *Network Analysis*, 3rd Edition, Pearson Education, 2015.

- T2. C. K. Alexander and M. N. O. Sadiku, *Fundamentals of Electric Circuits*, 5th Edition, Tata McGraw-Hill, 2013.
- T3. W. H. Hayt, J. Kemmerly, J. D. Phillips, and S. M. Durbin, *Engineering Circuit Analysis*, 9th Edition, McGraw-Hill Education, 2020.

Reference Books:

- R1. S. Ghosh, *Network Theory: Analysis And Synthesis*, 1st Edition, Prentice Hall of India, 2009.
- R2. P. K. Satpathy, P. Kabisatpathy, S. P. Ghosh, and A. K. Chakraborty, *Network Theory*, 1st Edition, Tata McGraw-Hill, 2009.
- R3. A. Chakrabarti, *Circuit Theory: Analysis and Synthesis*, 7th Edition, Dhanpat Rai & Co., 2013.
- R4. J. D. Irwin and R. M. Nelms, *Basic Engineering Circuit Analysis*, 11th Edition, Wiley, 2015.

Online Resources:

1. <https://nptel.ac.in/courses/108102042/>: by Prof. S. C. Dutta Roy, IIT Delhi
2. <https://nptel.ac.in/courses/108106075/>: by Prof. V. G. K. Murti, IIT Madras
3. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/lecture-notes/>

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

| | |
|-----|---|
| CO1 | Understand the concepts of network theorems, coupled circuits, resonant circuits & apply in solving complex networks problems. |
| CO2 | Understand the switching phenomena of electrical circuits and evaluate transient and steady state performance using Laplace Transformation. |
| CO3 | Analyze sinusoidal & non-sinusoidal signals using Fourier series and transform and apply in electrical & electronics circuit analysis. |
| CO4 | Determine two-port network parameters and their practical application to electrical and electronic circuits. |
| CO5 | Identify Network Functions and synthesize one port network using Foster and Cauer forms and analyze filter circuits.. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

Cont'd...

| | |
|------|--|
| PO6 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Digital Electronic Circuits | L-T-P | Credits | Marks |
|------|---------------|-----------------------------|-------|---------|-------|
| PC | BTEC-T-PC-010 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to understand the concepts & techniques associated with digital systems and their design & implementations in VLSI technology. |
| Pre-Requisites | Knowledge of Basic Electronics and fundamentals of Number Systems is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|----------------|
| Module-1 | Fundamental Concepts: Introduction, Digital Signals, Basic Digital Circuits, Different Logic Gates and their Logic Operations, Universal Logic Gates, Complete Logic Sets, Examples of Logic Gate ICs; Logic Families – TTL and CMOS Logic Families, Implementation of logic gates using TTL and CMOS logic; Number Systems and Codes: Number Systems, Binary Number System, Signed Binary Numbers, Binary Arithmetic, 1's and 2's Complement Arithmetic, Octal Number System, Hexadecimal Number System, Codes, Error Detecting and Correcting Codes. | 8 Hours |
| Module-2 | Combinational Logic Design: Boolean Algebra and Identities, Algebraic Reduction and Realization using Logic Gates and Universal Logic Gates; Standard Representation for Logic Functions: Sum-of-Products (SOP) and Product-of-Sums (POS) forms, Canonical SOP and POS forms; K-map representation and simplification of logic functions using K-map, Minimization of 2, 3, 4 variable logical functions; Don't care conditions; Combinational Logic Components: Multiplexer, De-Multiplexer, Decoders, Encoder (Priority Encoder), Design of Combinational Circuits using Multiplexer and Decoder, Adders, Subtractors, Carry-Look-Ahead Adder, Binary Multiplier, An Equality Detector and Comparator, BCD to 7-Segment Display Decoder. | 9 Hours |
| Module-3 | Sequential Logic Design(Flip-Flops and FSMs): Flip Flops – A 1-bit memory, Bistable latch (SR and D), the clocked SR flip flop, J-K, T and D type flip-flops, Race Around Condition, Master Slave JK-flip flop, Conversion of flip-flops; Finite State Machines (FSMs) – Mealy and Moore models of Finite State Machines. | 9 Hours |
| Module-4 | Sequential Logic Design (Shift Registers and Counters): Shift Registers – SISO, SIPO, PISO, PIPO and Universal Shift Register, Applications of Shift Registers (Serial to Parallel Converter, Parallel to Serial Converter), Ring Counter, Twisted Ring Counter (Johnson Counter); Counters – Design of Ripple (Asynchronous) Counters (Up/Down Counter, Mod-N Counter), Design of Synchronous Counters, Gray Code Counter and Random Sequence Counter using State Diagrams. | 8 Hours |

Cont'd...

| Module-# | Topics | Hours |
|----------|---|----------|
| Module-5 | Programmable Logic Devices: Programmable Logic Array (PLA), Programmable Array Logic (PAL), Complex Programmable Logic Devices (CPLDs); Semiconductor Memories: Basics of ROM, SRAM & DRAM; Basic Hardware Description Language: Introduction to VHDL/Verilog programming language, Different Modeling Styles (Dataflow, Behavioral and Structural), Data types and Objects, VHDL/Verilog program for combinational and sequential circuits. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. M. M. Mano and M. D. Ciletti, *Digital Design: With an Introduction to Verilog HDL*, 5th Edition, Pearson Education, 2013.
- T2. L. K. John and C. H. Roth Jr., *Digital System Design using VHDL*, 2nd Edition, Cengage Learning, 2012.

Reference Books:

- R1. D. V. Hall, *Digital Circuits and Systems*, International Student Edition, McGraw-Hill Education, 1989.
- R2. A. A. Kumar, *Fundamentals of Digital Circuits*, 3rd Edition, PHI Learning, 2014.
- R3. R. P. Jain, *Modern Digital Electronics*, 4th Edition, McGraw-Hill Education, 2009.
- R4. W. H. Gothmann, *Digital Electronics - An Introduction to Theory and Practice*, 2nd Edition, PHI Learning, 1982.
- R5. J. F. Wakerly, *Digital Design: Principles and Practices*, 4th Edition, Pearson Education, 2008.
- R6. J. P. Uyemura, *A First Course in Digital System Design : An Integrated Approach*, Vikas-Thomson Learning, 2002.
- R7. R. J. Tocci, N. S. Widemer, and G. L. Moss, *Digital Systems - Principles and Applications*, 11th Edition, Pearson Education, 2010.
- R8. A. Agarwal and J. Lang, *Foundations of Analog and Digital Electronic Circuits*, 1st Edition, Morgan Kaufmann, 2005.

Online Resources:

1. <https://nptel.ac.in/courses/117106086/>
2. <https://swayam.gov.in/course/1392-digital-circuits-and-systems>
3. <https://nptel.ac.in/courses/117103064/>
4. <https://nptel.ac.in/courses/117105080/3>
5. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/video-lectures/>
6. <http://www.allaboutcircuits.com>
7. <https://www.pannam.com/blog/free-resources-to-learn-electrical-engineering/>

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

| | |
|-----|---|
| CO1 | Become familiar with various number systems, codes and Boolean algebra. |
| CO2 | Design and analyze combinational logic circuits. |
| CO3 | Design & analyze various sequential logic circuits and be familiar with counter design. |
| CO4 | Design, analyze and implement memory array using sequential network for digital logic & investigate performance of CMOS based logic circuits in modern VLSI technology. |
| CO5 | Simulate and synthesize various digital circuits using VHDL in industry standard tools such as Xilinx, Mentor Graphics etc. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Analog Electronic Circuits | L-T-P | Credits | Marks |
|------|---------------|----------------------------|-------|---------|-------|
| PC | BTEI-T-PC-001 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to be familiar with Transistor (BJT, JFET and MOSFET) amplifiers, differential amplifiers and their implementations along with studying their characteristics & applications. |
| Pre-Requisites | Basic knowledge of semiconductor diodes and Bipolar Junction Transistors (BJT) is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Bipolar Junction Transistor (BJT) and its AC Analysis: Introduction to BJT DC Biasing Circuits, Design of different Biasing Circuits, Bias Stability, Introduction to BJT small signal model, r_e and h -models of different configurations (CB, CE, and CC), r_e and h -models of different biasing circuits, Effect of R_S and R_L , Standard ICs. | 9 Hours |
| Module-2 | Field Effect Transistor (FET) and its AC Analysis: JFET DC Biasing Circuits (Fixed, Self and Voltage divider), MOSFET DC Biasing Circuits, Introduction to JFET and MOSFET small signal model, Small signal model of different configurations (CG, CD, and CS), Small signal model of different biasing circuits of MOSFET, Effect of R_S and R_L , Standard ICs. | 9 Hours |
| Module-3 | Compound Configurations: CMOS and its circuit realization, Darlington pair, Current Mirror, Cascade & Cascode configuration. Frequency Response Analysis: Low Frequency Response of BJT, High Frequency Response of BJT, Low Frequency Response of FET, Miller's Effect, Multistage Frequency Effects, Gain-Bandwidth Relation. | 8 Hours |
| Module-4 | Operational Amplifiers: Introduction to OP-AMP, Applications of OP-AMP: Summing, Buffer, Log Differentiator, Schmitt Trigger and Integrator, Introduction to Differential Amplifier, DC and AC Analysis of Differential Amplifier, Instrumentation Amplifier, Active Filters, Standard ICs. | 8 Hours |
| Module-5 | Feedback Amplifiers: Introduction to Feedback Amplifiers, Feedback Topologies, Derivation of different parameters (Z_i , Z_o , A_v , A_i), Practical feedback circuits, Standard ICs. Oscillators: Introduction to Oscillators, High Frequency Oscillators: Hartley and Crystal Oscillators, Standard ICs. Power Amplifiers: Introduction to Power Amplifiers, Classification of Power Amplifiers: Class A, Class B, Class C, Push-Pull Amplifiers, Standard ICs. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. A. S. Sedra and K. C. Smith, *Microelectronic Circuits: Theory and Applications (International Version)*, 7th Edition, Oxford University Press, 2017.
- T2. R. L. Boylestad and L. Nashelsky, *Electronic Devices and Circuit Theory*, 11th Edition, Pearson Education, 2013.
- T3. J. V. Wait, L. P. Huelsman, and G. A. Korn, *Introduction to Operational Amplifier Theory and Applications*, McGraw-Hill USA, 1992.
- T4. J. Millman and A. Grabel, *Microelectronics*, 2nd Edition, McGraw-Hill Education, 2017.

Reference Books:

- R1. J. Millman and C. C. Halkias, *Integrated Electronics: Analog and Digital Circuits and Systems*, 2nd Edition, TMH Publications, 2017.
- R2. A. Malvino and D. J. Bates, *Electronic Principles*, 7th Edition, McGraw-Hill, 2017.
- R3. P. Horowitz and W. Hill, *The Art of Electronics*, 2nd Edition, Cambridge University Press, 1989.
- R4. P. R. Gray, P. J. Hurst, R. G. Meyer, and S. H. Lewis, *Analysis and Design of Analog Integrated Circuits*, 5th Edition, John Wiley & Sons, 2009.

Online Resources:

1. <https://nptel.ac.in/courses/117101106/>
2. <https://nptel.ac.in/courses/108102095/>
3. <http://www.electrical4u.com/circuit-analysis.htm>
4. <http://www.allaboutcircuits.com>
5. <https://www.electronics-tutorials.ws/>

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

| | |
|-----|--|
| CO1 | Design different biasing methods and small signal models of BJT and estimate the performance parameters of different amplifier configurations. |
| CO2 | Analyze the structural behavior, characteristics and different biasing configurations of JFET and MOSFET. |
| CO3 | Understand and analyze the structural configuration of multi-stage amplifier and plot its frequency response. |
| CO4 | Study the construction and characteristics of an Op-Amp and design circuits for various linear applications using Op-Amp. |
| CO5 | Design various industrial circuits such as oscillators & negative feedback amplifiers using transistors and validate their experimental results. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |

Cont'd...

| | |
|------|---|
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Signals & Systems | L-T-P | Credits | Marks |
|------|---------------|-------------------|-------|---------|-------|
| PC | BTEC-T-PC-007 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to study the presentation of various signals in time and spectrum domains, and stability & causality of LSI systems. |
| Pre-Requisites | Fundamental knowledge of basic mathematics is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Signals: Introduction, Classification: continuous/ discrete-time, commonly used continuous-time signals and discrete-time Signals, Analog/ digital signal, Periodic/ aperiodic, Even/ odd, Energy/ power, Deterministic/ random, Operation on Continuous-time and Discrete time signals: Addition, Multiplication, Differentiation/Difference, Integration/Accumulation, Shifting, Scaling, Folding and Convolution (graphical and analytical), Correlation of Discrete-Time signals & its properties. | 8 Hours |
| Module-2 | System and LTI/LSI System: Introduction, Classification for both continuous time and discrete time - Linear/ Non-linear, Time varying/ time invariant, Causal/ non-causal, Dynamic/ static, Stable/ unstable and Invertible/ Non-invertible, Continuous time and Discrete time LSI system, System representation through differential equations and difference equations, Response of LSI system and convolution Integral/convolution Sum, Characterization of causality and stability of linear shift invariant(LSI). | 8 Hours |
| Module-3 | Analysis by Fourier series and Fourier Transform: Orthogonal and Ortho-normal signal set, Fourier series, convergence of the Fourier series, Trigonometric Fourier series and exponential Fourier series, Continuous time Fourier Transform, convergence of the Fourier transform, Fourier transform of some useful signals, properties of the Fourier transform, the notion of a frequency response and its relation to the impulse response, Parseval's theorem: Energy spectral density, Power spectral density. | 9 Hours |
| Module-4 | Analysis by Laplace Transform: Introduction, Region of Convergence for Laplace transform, and properties of ROC, Laplace transform of some useful signals, properties of the Laplace transform, the inverse Laplace transform and Unilateral Laplace Transform and their properties, Initial value and final value theorem, solution of differential equation using Laplace transform. | 9 Hours |
| Module-5 | Analysis by Z-Transform: Discrete-time system analysis using the Z-transform, Mapping from S-plane to Z-plane, Z-transform, The Region of Convergence, Z-transform of some useful sequences, Properties of Z-transform, Inverse Z-transform, Unilateral Z-Transform and its properties. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. A. V. Oppenheim, A. S. Willsky, and S. H. Nawab, *Signals and Systems*, 2nd Edition, Prentice Hall India, 1992.
- T2. S. Haykin and B. V. Veen, *Signals and Systems*, 2nd Edition, John Wiley & Sons, 2002.
- T3. B. P. Lathi, *Principles of Signal Processing and Linear Systems*, 2nd Edition, Oxford University Press, 2009.

Reference Books:

- R1. A. Ambardar, *Analog and Digital Signal Processing*, 2nd Edition, Brooks/Cole Publishing, 1999.
- R2. H. P. Hsu, *Signal and System - Schaum's Outlines*, 2nd Edition, McGraw Hill, 2011.
- R3. M. J. Roberts, *Signals and Systems - Analysis using Transform methods and MATLAB*, 2nd Edition, McGraw Hill, 2003.
- R4. A. N. Kani, *Signals and System*, 2nd Edition, McGraw Hill Education, 2010.

Online Resources:

1. <https://nptel.ac.in/courses/117104074/>: by Prof. K.S. Venkatesh, IIT Kanpur
2. <https://nptel.ac.in/courses/108105065/>: by Prof. T.K. Basu, IIT Kharagpur
3. <https://nptel.ac.in/courses/108104100/>: by Prof. A. K. Jagannatham, IIT Kanpur
4. <https://nptel.ac.in/courses/108105059/>: by Prof. S. Mukhopadhyay, IIT Kharagpur
5. <https://ocw.mit.edu/resources/res-6-007-signals-and-systems-spring-2011/lecture-notes/>
6. <https://engineering.purdue.edu/~mikedz/ee301/ee301.html>
7. <https://stanford.edu/~boyd/ee102/>

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

| | |
|-----|---|
| CO1 | Describe different types of signals and systems. |
| CO2 | Analyze various types of LSI systems responses. |
| CO3 | Represent continuous and discrete systems in time & frequency domains using different transforms. |
| CO4 | Investigate the system stability and causality using Laplace Transform and Z-Transform. |
| CO5 | Analyze discrete time signals and systems using Z-transform. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

Cont'd...

| | |
|-----|--|
| PO6 | 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. |
|-----|--|

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | OOP Using Java Lab | L-T-P | Credits | Marks |
|------|---------------|--------------------|-------|---------|-------|
| ES | BTCS-P-ES-006 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of the course is to apply object oriented programming principles and implement object oriented programming using JAVA language. |
| Pre-Requisites | Basic analytical and logical understanding including basic knowledge and usage of computers is required for this course. Prior experience with any other object oriented programming language will be beneficial. |
| Teaching Scheme | Regular laboratory classes with the use of ICT whenever required, demonstration through practical simulation of code using IDE. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|--|
| 1 | Understanding Java platform, compilation, and execution of a java program. |
| 2 | Overview of Eclipse IDE. |
| 3 | Use of class, use of control statements, data types, operators. |
| 4 | Implement class, object, constructor, methods, and other OOP features. |
| 5 | Inheritance Basics, more uses of constructor, method overriding, use of final. |
| 6 | Object class, practical use of abstract class. |
| 7 | Using Interface for achieving multiple inheritance, implementation of package. |
| 8 | Exception handling fundamentals, java built-in exceptions, Use of Scanner class for console input, use of own Exception subclass. |
| 9 | Java thread life cycle model and implementation approach, thread priority, implementation of synchronization. |
| 10 | I/O Basics, byte stream and character streams, reading and writing files, text processing using Java pre-defined stringBuilder and stringBuffer classes. |
| 11 | Basics of Java collection framework, implementation of collections in Java with different programs. |
| 12 | GUI basics and Window fundamentals, working with different Component, Container and Layout Managers. |
| 13 | Event handling for interactive GUI application. |
| 14 | Final lab test and viva voce. |

Text Books:

- T1. H. Schildt, *Java: The Complete Reference*, 9th Edition, McGraw-Hill, 2011.
- T2. Y. D. Liang, *Introduction to Java Programming*, 9th Edition, Pearson Education, 2012.

Reference Books:

- R1. B. Bates, K. Sierra, *Head First Java*, 2nd Edition, O'Reilly Media, 2005.
- R2. T. Budd, *An Introduction to Object-Oriented Programming*, 3rd Edition, Pearson Education, 2009.
- R3. I. Horton, *Beginning Java*, 7th Edition, Wrox Publications, 2011.

Online Resources:

1. <https://nptel.ac.in/courses/106105191/>
2. <https://docs.oracle.com/javase/tutorial/>
3. <http://www.javatpoint.com/java-tutorial>
4. <http://www.w3schools.in/java/>
5. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-00-introduction-to-computer-science-and-programming-fall-2008/video-lectures/lecture-14/>

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

| | |
|-----|--|
| CO1 | Apply object oriented programming to develop Java programs for real-life applications. |
| CO2 | Employ inheritance techniques for developing reusable software. |
| CO3 | Develop robust and concurrent programs using exception handling and multi-threading. |
| CO4 | Design programs using I/O operations, String classes and collection framework. |
| CO5 | Design GUI applications using AWT and Swing. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO6 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Circuit Theory Lab | L-T-P | Credits | Marks |
|------|---------------|--------------------|-------|---------|-------|
| PC | BTEE-P-PC-004 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of the course is to provide practical working knowledge of network theory and recording the experimental data effectively and correctly. |
| Pre-Requisites | Basic knowledge of electrical & electronics engineering, Laplace transform and differential equations is required. |
| Teaching Scheme | Regular laboratory experiments to be conducted using hardware and software tools under the supervision of the teacher. Demonstration along with required safety measures will be explained for each experiment. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|--|
| 1 | Verification of Network Theorems (Superposition, Thevenin, Norton, Maximum Power Transfer) both in DC & AC. |
| 2 | Determination of two port network parameters: Open Circuit(z), Short Circuit(y), Hybrid(h) and Transmission (ABCD) parameters |
| 3 | Frequency response of Low pass and High Pass Filters. |
| 4 | Determination of self-inductance, mutual inductance and coupling coefficient of a single phase two winding transformer representing a coupled circuit. |
| 5 | Study of resonance in R-L-C series & parallel circuit. |
| 6 | Verification of Network Theorems by modelling and simulation (Superposition, Thevenin, Norton, Maximum Power Transfer) both in DC & AC. |
| 7 | Modelling of two port networks and determination of parameters by simulation. |
| 8 | Frequency response of Low pass, High pass and Band pass Filters using simulation. |
| 9 | Modelling and simulation of DC and AC Transients in electrical circuits. |
| 10 | To study the characteristics of Single tuned and double tuned circuit. |
| 11 | Spectral analysis of a non-sinusoidal waveform. |

Text Books:

- T1. M. E. Van Valkenburg, *Network Analysis*, 3rd Edition, Pearson Education, 2015.
- T2. C. K. Alexander and M. N. O. Sadiku, *Fundamentals of Electric Circuits*, 5th Edition, Tata McGraw-Hill, 2013.
- T3. W. H. Hayt, J. Kemmerly, J. D. Phillips, and S. M. Durbin, *Engineering Circuit Analysis*, 9th Edition, McGraw-Hill Education, 2020.

Reference Books:

- R1. S. Ghosh, *Network Theory: Analysis And Synthesis*, 1st Edition, Prentice Hall of India, 2009.
- R2. P. K. Satpathy, P. Kabisatapathy, S. P. Ghosh, and A. K. Chakraborty, *Network Theory*, 1st Edition, Tata McGraw-Hill, 2009.
- R3. A Chakrabarti, *Circuit Theory: Analysis and Synthesis*, 7th Edition, Dhanpat Rai & Co., 2013.
- R4. J. D. Irwin and R. M. Nelms, *Basic Engineering Circuit Analysis*, 11th Edition, Wiley, 2015.

Online Resources:

1. <https://nptel.ac.in/courses/108102042/>: by Prof. S. C. Dutta Roy, IIT Delhi
2. <https://nptel.ac.in/courses/108106075/>: by Prof. V. G. K. Murti, IIT Madras
3. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/lecture-notes/>

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

| | |
|-----|---|
| CO1 | Gain knowledge on procedures to conduct experiments safely, analyze results and develop technically sound report of outcomes. |
| CO2 | Relate the co-relation between frequency and circuit parameters at resonance condition. |
| CO3 | Design and analyze different configurations in electrical networks using modern software. |
| CO4 | Employ concept of coupled circuits to electrical machines. |
| CO5 | Analyze sinusoidal & non-sinusoidal signals using Fourier series and transform. |
| CO6 | Design various filters and tuned amplifiers, and examine their frequency response. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|
| CO1 | 3 | 3 | 1 | 1 | 1 | 1 | | | | | | 2 | 3 | 1 | 1 |
| CO2 | 2 | 1 | 1 | 2 | 1 | | | | | | | 1 | 2 | 1 | |
| CO3 | 2 | 2 | 2 | 3 | 3 | | | | | | | 1 | 2 | 2 | 1 |
| CO4 | 1 | 1 | 1 | 1 | 1 | | | | | | | 1 | 1 | | |
| CO5 | 3 | 3 | 1 | 1 | 1 | | | | | | | 2 | 2 | 1 | |
| CO6 | 3 | 2 | 1 | 3 | 2 | 1 | | | | | | 2 | 2 | 1 | |

| Type | Code | Digital Electronic Circuits Lab | L-T-P | Credits | Marks |
|------|---------------|---------------------------------|-------|---------|-------|
| PC | BTEC-P-PC-011 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of the course is to hands-on exposure on logic gates, implementation using Boolean algebra, designing digital circuits like counters, registers and apply the knowledge to formulate digital systems using HDL. |
| Pre-Requisites | Knowledge of Basic Electronics is required. |
| Teaching Scheme | Regular laboratory experiments to be conducted under supervision of the faculty with use of ICT as and when required, sessions are planned to be interactive with focus on implementation in hardware / software tools. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|---------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|--|
| 1 | Digital Logic Gates: Investigate logic behaviour of AND, OR, NAND, NOR, EX-OR, EX-NOR, Invert and Buffer gates, use of Universal NAND Gate. |
| 2 | Combinational Circuit Design: Design, assemble and test: adders and subtractors. |
| 3 | Combinational Circuit Design: Code Converters, Gray code to Binary and 7 Segment Display. |
| 4 | Universal Gates: Design, implement and test a given design example with (i) NAND Gates only (ii) NOR Gates only and (iii) using minimum number of Gates. |
| 5 | Multiplexer and De-multiplexer: Design with multiplexers and de-multiplexers. |
| 6 | Flip-Flop: Assemble, test and investigate operation of SR, D & J-K flip-flops. |
| 7 | Shift Registers: Design and investigate the operation of all types of shift registers. |
| 8 | Counters: Design, assemble and test various ripple and synchronous counters - decimal counter, Binary counter with parallel load. |
| 9 | Parallel Adder and Accumulator: Design, implement and test. |
| 10 | Binary Multiplier: design and implement a circuit that multiplies 4-bit unsigned numbers to produce an 8-bit product. |
| 11 | Memory Unit: Investigate the behaviour of RAM unit and its storage capacity – 16×4 RAM: testing, simulating and memory expansion. |
| 12 | Clock-pulse generator: Design, implement and test. |
| 13 | Verilog/VHDL Simulation and implementation of Experiments 2 to 12. |

Text Books:

- T1. M. M. Mano and M. D. Ciletti, *Digital Design: With an Introduction to Verilog HDL, VHDL and System Verilog*, 6th Edition, Pearson Education, 2018.

Reference Books:

- R1. A. M. Michelén, *Digital Electronics Laboratory Manual*, Pearson Education, 2000.
 R2. J. W. Stewart and C. -Y. Wang, *Digital Electronics Laboratory Experiments: Using the Xilinx XC95108 CPLD with Xilinx Foundation : Design and Simulation Software*, 2nd Edition, Pearson, 2004.

Online Resources:

1. <https://www2.mvcc.edu/users/faculty/jfiore/Resources/DigitalElectronics1LaboratoryManual.pdf>
2. <https://www.elprocus.com/top-digital-electronic-projects-for-electronics-engineering-students/>
3. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-111-introductory-digital-systems-laboratory-spring-2006/>

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

| | |
|-----|--|
| CO1 | Analyse the function of logic gates and implementation of Boolean functions. |
| CO2 | Realize Universal gates and Implementation of minimized Boolean Expressions. |
| CO3 | Design and analyze different combinational circuits. |
| CO4 | Design various asynchronous and Synchronous Sequential Circuits. |
| CO5 | Acquire knowledge about internal circuitry and logic behind any digital system. |
| CO6 | Simulate various digital circuits using VHDL in industry standard tool such as Xilinx. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|
| CO1 | 2 | 3 | 2 | 3 | 2 | 1 | | | | | | | 3 | 1 | |
| CO2 | 2 | 3 | 3 | 3 | 3 | 1 | | | | | | | 3 | 1 | |
| CO3 | 2 | 3 | 3 | 3 | 3 | 1 | | | | | | | 3 | 1 | |
| CO4 | 2 | 3 | 2 | 3 | 2 | 1 | | | | | | | 3 | 1 | |
| CO5 | 2 | 3 | 2 | 3 | 2 | 1 | | | | | | | 3 | 1 | |
| CO6 | 2 | 3 | 2 | 3 | 2 | 1 | | | | | | | 3 | 1 | |

| Type | Code | Analog Electronic Circuits Lab | L-T-P | Credits | Marks |
|------|---------------|--------------------------------|-------|---------|-------|
| PC | BTEI-P-PC-002 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of the course is to design, implement and test transistor biasing, amplifying action and frequency response. Also study the linear and nonlinear applications of amplifiers. |
| Pre-Requisites | Basic analytical and logical understanding including basic knowledge of Basic electronics is required. |
| Teaching Scheme | Regular laboratory experiments to be conducted under supervision of the teacher with focus on implementation in hardware/software tools. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|---------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|--|
| 1 | Design and simulate BJT bias circuit and compare the results. |
| 2 | Design and simulate JFET/MOSFET bias circuit and compare the results. |
| 3 | Design and simulate BJT common-emitter circuit and compare DC and AC performance. |
| 4 | Design and simulate JFET/MOSFET common-source circuit and compare DC and AC performance. |
| 5 | Determining the frequency response of a common-emitter amplifier: low frequency, high frequency and mid frequency response and compare with simulated results. |
| 6 | Differential amplifier circuits: DC bias & AC operation with & without current source. |
| 7 | Study of Darlington connection and current mirror circuits. |
| 8 | OP-Amp Frequency Response and Compensation. |
| 9 | Application of Op-Amp as differentiator, integrator, square wave generator. |
| 10 | Obtain the band width of FET/BJT using Square wave testing of an amplifier. |
| 11 | RC phase shift oscillator/Wien-Bridge Oscillator using Op-Amp/Crystal Oscillator. |
| 12 | Class A and Class B Power Amplifiers. |

Text Books:

- T1. R. L. Boylestad and L. Nashelsky, *Electronic Devices and Circuit Theory*, 10th Edition, Pearson Education, 2009.

Reference Books:

- R1. L. K. Maheshwari and M. M. S. Anand, *Laboratory Experiments and PSPICE Simulations in Analog Electronics*, PHI Learning, 2006.
 R2. L. K. Maheshwari and M. M. S. Anand, *Laboratory Manual for Introductory Electronics Experiments*, John Wiley & Sons, 1980.
 R3. K. A. Navas, *Electronics Lab Manual, Vol-2*, 6th Edition, PHI Learning, 2018.

Online Resources:

1. <http://www2.ece.ohio-state.edu/ee327/>
2. https://wiki.analog.com/university/courses/alm1k/alm_circuits_lab_outline
3. <https://wiki.analog.com/university/courses/electronics/labs>

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

| | |
|-----|--|
| CO1 | Design, assemble and test BJT biasing circuits. |
| CO2 | Analyze the Dc and Ac performance of BJT and FET. |
| CO3 | Understand the frequency response of single & multi-stage BJT and compare the results. |
| CO4 | Study operational amplifier and its various applications. |
| CO5 | Analyze and design various wave shaping circuits. |
| CO6 | Implement different oscillator circuits and analyze power amplifier characteristics. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|
| CO1 | 3 | 3 | 2 | 3 | 2 | | | | | | | 1 | 3 | 1 | 1 |
| CO2 | 3 | 3 | 2 | 3 | 2 | | | | | | | | 3 | 1 | 1 |
| CO3 | 3 | 3 | 2 | 3 | 3 | | | | | | | | 3 | 2 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 3 | | | | | | | | 3 | 1 | 2 |
| CO5 | 3 | 2 | 2 | 3 | 2 | | | | | | | 1 | 3 | 2 | 3 |
| CO6 | 3 | 2 | 3 | 3 | 3 | | | | | | | | 3 | 3 | 2 |

| Type | Code | Mathematics-IV for Electrical Sciences | L-T-P | Credits | Marks |
|------|---------------|--|-------|---------|-------|
| BS | BTBS-T-BS-025 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to provide the knowledge of vector calculus, partial differential equations & numerical methods, along with the applications of these methods in engineering. |
| Pre-Requisites | Knowledge of calculus of single variable, coordinate geometry of two and three dimensions, and ordinary differential equations is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Partial derivatives, Chain rule Maxima minima in several variables; Vector and scalar functions and fields, derivatives, Directional derivative & gradient of a scalar field, Divergence & Curl of a vector field. | 8 Hours |
| Module-2 | Vector line integrals, Line integrals independent of path, Double integrals, Green's theorem in the plane Surfaces, Surface integrals, Triple integrals, Gauss divergence theorem, Stoke's theorem. | 10 Hours |
| Module-3 | Basic Concepts of PDEs, One Dimensional Wave Equation and its solutions, One Dimensional Heat Equation and its solutions, Two dimensional heat equation, Laplace Equation, Solution of Laplace equation in cylindrical and spherical coordinates. | 10 Hours |
| Module-4 | Error Analysis, Solution of Nonlinear Equations, Bisection Method, Fixed-Point Iteration Method, Secant Method, Newton Method, Interpolation by Polynomials: Lagrange Interpolation, Newton Divided Differences, Newton's forward & backward Interpolation. | 7 Hours |
| Module-5 | Numerical Differentiation and Integration, Trapezoidal, Simpson's Rules, Composite Rules, Error Formulae, Gaussian Quadrature Rules, Solution of Differential Equations by Euler Method, Modified Euler Method, and Runge-Kutta Methods. | 7 Hours |
| Total | | 42 Hours |

Text Books:

T1. E. Kreyszig, *Advanced Engineering Mathematics*, 8th Edition, Wiley India, 2015.

Reference Books:

R1. S. Pal and S. C. Bhunia, *Engineering Mathematics*, 1st Edition, Oxford University Press, 2015.

R2. B. V. Ramana, *Higher Engineering Mathematics*, 1st Edition, McGraw-Hill, 2017.

Online Resources:

1. <http://www.nptel.ac.in/courses/111105035>
2. <http://www.nptel.ac.in/courses/122104017>
3. <http://nptel.ac.in/courses/122102009>

4. <http://nptel.ac.in/courses/111107063>
5. <https://www.coursera.org/learn/linearalgebra2>
6. <https://www.coursera.org/learn/differentiation-calculus>
7. <https://www.coursera.org/learn/single-variable-calculus>
8. <https://alison.com/courses/Algebra-Functions-Expressions-and-Equations>

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

| | |
|-----|--|
| CO1 | Understand the concepts vector differential calculus and their applications. |
| CO2 | Understand the concepts vector integral calculus and their applications. |
| CO3 | Solve partial differential equations for engineering applications and interpret the solution. |
| CO4 | Find the root of non-linear and transcendental equations using numerical methods and interpolate a data. |
| CO5 | Perform numerical integration and solve ordinary differential equations using various numerical methods. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Basics of Mechanical Engineering | L-T-P | Credits | Marks |
|------|---------------|----------------------------------|-------|---------|-------|
| ES | BTBS-T-ES-013 | | 3-1-0 | 4 | 100 |

| | |
|------------------------|---|
| Objectives | The objectives of this course is to introduce basics of mechanical engineering, such as, statics, force equilibrium, free body diagrams, analysis of beams and associated stresses, laws of Thermodynamics and their applications in Power Plants and IC engines, and elements of fluid statics, which are essential and useful in every branch of engineering. |
| Pre-Requisites | Basic analytical and logical skills, a working knowledge of Physics and Mathematics including introductory calculus are required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Introduction to Engineering Mechanics: Basic concepts, System of Forces, Coplanar Concurrent Forces, Resultant-Moment of Forces and its application; Couples, Moment (about point and about axis), Varignon's theorem, Resultant of concurrent and non-concurrent coplanar forces, Static equilibrium, Free body diagram, Reactions; Friction, Laws of Coulomb friction; Problems involving large and small contact surfaces (Ladder and Wedges); Square threaded screws (self-locking, screw jack); Belt friction; Rolling resistance. | 12 Hours |
| Module-2 | Mechanical Properties of Materials: Stress-Strain behaviour, Brittle and Ductile materials, selection of materials, Impact Test; Analysis of Beams: Centre of Gravity and Moment of Inertia of a plane and composite sections; Types of Beams, Loads and Reactions, Shear Forces, Bending Moments; Bending of Beams, Bending Stresses and Shear Stresses in beams, Failure of Beams (in brief). | 12 Hours |
| Module-3 | Basics of Thermodynamics: System, Control Volume, Surrounding, Boundaries, Macroscopic and Microscopic approaches, Thermodynamic Equilibrium, State, Property, Process, Point and Path functions, Cycle, Reversibility and Irreversibility; Properties of pure substances and phase change, Property diagrams, Use of Steam Tables; Brief discussion on Zeroth Law, First law and Second Law of Thermodynamics. | 12 Hours |
| Module-4 | Applications of Thermodynamics: Brief description and working principles of Air Compressors, Steam Power Plant, Refrigerators and Heat Pump, I.C. Engines (two-stroke and four-stroke, petrol and diesel engines). | 10 Hours |
| Module-5 | Fluid Properties and Fluid Statics: Properties of a Fluid; Pascal's Law, Simple and Differential manometers, Hydrostatic forces on submerged surfaces, Buoyancy, Bernoulli's theorem. | 10 Hours |
| Total | | 56 Hours |

Text Books:

- T1. S. Timoshenko, D. H. Young, S. Pati, and J. V. Rao, *Engineering Mechanics*, 5th Edition, McGraw-Hill, 2013.
- T2. G. H. Ryder, *Strength of Materials*, 3rd Edition, Macmillan Press, 1969.
- T3. R. E. Sonntag, C. Borgnakke, and G. J. Van Wylen, *Fundamentals of Thermodynamics*, 9th Edition. John Wiley & Sons, 2017.
- T4. S. K. Som, G. Biswas, and S. Chakraborty, *An Introduction to Fluid Mechanics and Fluid Machines*, 3rd Edition, McGraw- Hill Education, 2012.

Reference Books:

- R1. P. K. Nag, *Engineering Thermodynamics*, 4th Edition, McGraw-Hill, 2008.
- R2. R. K. Rajput, *Strength of Materials: Mechanics of Solids*, 7th Edition, S. Chand Publications, 2018.
- R3. R. K. Bansal, *A Textbook of Fluid Mechanics and Hydraulic Machines*, 9th Edition, Laxmi Publications, 2010.

Online Resources:

1. <https://nptel.ac.in/courses/122104015/>: Engineering Mechanics by Prof. M. Harbola, IIT Kanpur.
2. <https://nptel.ac.in/courses/112/105/112105123/>: Basic Thermodynamics by Prof. S. K. Som, IIT Kharagpur
3. <https://nptel.ac.in/courses/112/105/112105171/>: Basics of Fluid Mechanics by Prof. S. K. Som, IIT Kharagpur
4. <https://nptel.ac.in/courses/105/105/105105108/>: Strength of Materials by Prof. S. Bhattacharya, IIT Kharagpur)

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

| | |
|-----|--|
| CO1 | Explain and analyze the principles of mechanics to solve problems in statics. |
| CO2 | Articulate mechanics of deformable bodies and mechanical properties of materials. |
| CO3 | Understand and solve problems in thermodynamics of pure substances. |
| CO4 | Explain the design and operation of various devices based on thermodynamic principles. |
| CO5 | Analyze the behavior of fluids and apply the concepts to solve problems in hydrostatics. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

| | | | | | | | | | | | | | | | |
|-----|---|---|---|---|---|--|--|--|--|--|--|--|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 1 | | | | | | | | 1 | 1 | |
| CO2 | 2 | 2 | 2 | 2 | 1 | | | | | | | | 1 | 1 | |
| CO3 | 3 | 3 | 3 | 2 | 1 | | | | | | | | 1 | 1 | 1 |
| CO4 | 1 | 2 | 3 | 1 | 1 | | | | | | | | | 1 | 1 |
| CO5 | 3 | 1 | 2 | 2 | 1 | | | | | | | | 1 | 2 | 1 |

| Type | Code | Digital Signal Processing | L-T-P | Credits | Marks |
|------|---------------|---------------------------|-------|---------|-------|
| PC | BTEC-T-PC-017 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to study processing of digital signals using Z-transform, discrete Fourier transform, design of IIR & FIR filters, and the concepts of multi-rate signal processing. |
| Pre-Requisites | Basic knowledge of signals and systems is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Discrete Time Signals: Z-Transform, Region of convergence, Properties, Inverse Z-transform (power series & partial fraction), Analysis of LSI Systems: causality & stability using Z-transform, pole-zero concept and cancellation, transient & steady state response, Unilateral Z-transform & its properties, solution of difference equations. | 8 Hours |
| Module-2 | Basics of Discrete Time Fourier Transform (DTFT), frequency domain sampling & reconstruction of discrete time signals; Discrete Fourier Transform (DFT), properties; Linear filtering (overlap add and overlap save), Efficient computation of DFT: Fast Fourier Transform (FFT) Algorithm (Radix-2 DIT and Radix-2 DIF). | 9 Hours |
| Module-3 | Structure for Realization of Discrete Time Systems: Structure for IIR Systems - Direct Form I, Direct Form II, Cascade and Parallel Form, Signal Flow Graph and Transposed Structure; Structure for FIR Systems - Direct Form, Cascade Form and Frequency Sampling Structure. | 9 Hours |
| Module-4 | Design of Digital Filters: Causality and its implication; Design of FIR filters - symmetric and anti-symmetric, design of Linear Phase FIR filters using Windowing & Frequency Sampling; Design of IIR Filters from analog filters using Impulse invariance & bilinear transformation. | 9 Hours |
| Module-5 | Introduction to Multi-rate Signal Processing: Interpolation, Decimation, sampling rate conversion by rational factor; Implementation of sampling rate conversion by poly-phase filter structure. | 7 Hours |
| Total | | 42 Hours |

Text Books:

- T1. J. G. Proakis and D. G. Manolakis, *Digital Signal Processing : Principles, Algorithms and Applications*, 4th Edition, Prentice Hall India, 2007.
- T2. A. V. Oppenheim, A. S. Willsky, and S. H. Nawab, *Signals and Systems*, 2nd Edition, Prentice Hall India, 1992.
- T3. S. K. Mitra, *Digital Signal Processing : A Computer Based Approach*, 4th Edition, McGraw Hill, 2013.

P.T.O

Reference Books:

- R1. L. R. Rabiner and B. Gold, *Theory and Application of Digital Signal Processing*, 2nd Edition, Prentice Hall India, 1992.
- R2. J. R. Johnson, *Introduction to Digital Signal Processing*, 2nd Edition, Prentice Hall India, 1992.
- R3. A. N. Kani, *Digital Signal Processing*, 2nd Edition, McGraw Hill Education, 2017.
- R4. P. R. Babu, *Digital Signal Processing*, 4th Edition, Scitech Publication, 2011.

Online Resources:

1. <https://nptel.ac.in/courses/108/106/108106151/>: by Prof. C. S. Ramalingam, IIT Madras
2. <https://nptel.ac.in/courses/117102060/>: by Prof. S. C. Dutta Roy, IIT Delhi
3. <https://nptel.ac.in/courses/117104070/>: by Prof. T. K. Basu, IIT Kharagpur

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

| | |
|-----|---|
| CO1 | Explain the stability and causality of the LSI systems using Z-Transform. |
| CO2 | Analyze discrete signals & systems using DFT technique. |
| CO3 | Realize different structures of FIR and IIR discrete time systems. |
| CO4 | Design IIR and FIR filters using various techniques. |
| CO5 | Describe the basics of Multi-rate Signal Processing. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Analog Communication | L-T-P | Credits | Marks |
|------|---------------|----------------------|-------|---------|-------|
| PC | BTEC-T-PC-008 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to study electronic communication systems, modulation techniques, digital transmission of analog signal, random variables, sources of noise and noise in Amplitude and Frequency modulation. |
| Pre-Requisites | Basic knowledge of signals and systems, trigonometry, and probability theory is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Signals and Spectra: An Overview of Electronic Communication Systems, Types of Signals, Fourier Series, Fourier Transform, Properties of Fourier Transform, Orthogonal Signals. | 8 Hours |
| Module-2 | Amplitude Modulation Systems: Need for modulation, Double Side Band with Carrier (DSB-C) and Suppressed Carrier (DSB-SC), Modulators - Square-law, Switching, Balanced, Detectors - Square-law, Envelope, Synchronous, Single Side Band Suppressed Carrier (SSB-SC), Frequency & Phase discrimination methods, Coherent detection, Vestigial Side Band (VSB) Modulation & Demodulation, Frequency Division Multiplexing, Radio Transmitter and Receiver (Super Heterodyne Receiver). | 9 Hours |
| Module-3 | Angle Modulation: Angle Modulation, Narrow & Wide band FM, FM Modulators - Direct method (Varactor diode), Indirect method (Armstrong), Detectors - Simple slope, Balanced Slope, Phase Locked Loop (PLL); Pulse Modulation: Sampling Theorem, Modulation - Pulse Amplitude, Pulse Width, and Pulse Position. | 9 Hours |
| Module-4 | Mathematical Representation of Noise: Sources of Noise, Frequency-domain representation, Superposition of Noises, Linear Filtering, Noise Bandwidth. Noise in AM System: Framework for Amplitude Demodulation, Calculation of Signal to Noise Ratio - SSB-SC, DSB-SC, and DSB-C. | 8 Hours |
| Module-5 | Noise in FM System: An FM Receiving System, Calculation of Signal to Noise Ratio, Comparison of FM and AM, Pre-emphasis and De-emphasis, SNR improvement, Threshold in FM, The FM Demodulator using Feedback (FMFB). | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. H. Taub, D. L. Schilling, and G. Saha, *Principles of Communication System*, 4th Edition, Tata McGraw Hill, 2013.

T2. R. P. Singh and S. D. Sapre, *Communication Systems : Analog and Digital*, 3rd Edition, McGraw Hill Education, 2012.

Reference Books:

- R1. M. Salehi and J. G. Proakis, *Communication System Engineering*, 2nd Edition, PHI, 2002.
 R2. S. Haykin and M. Moher, *Communication Systems*, 5th Edition, John Wiley & Sons, 2009.
 R3. B. P. Lathi, Z. Ding, and H. M. Gupta, *Modern Digital and Analog Communication Systems*, 4th Edition, Oxford University Press, 2017.

Online Resources:

1. <https://nptel.ac.in/courses/117/105/117105143/>: by Prof. G. Das, IIT Kharagpur
2. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/117105143/lec60.pdf
3. <http://www.digimat.in/nptel/courses/video/117105143/L22.html>
4. <http://www.nptelvideos.in/2012/11/communication-engineering.html>

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

| | |
|-----|--|
| CO1 | Explain different types of signals and their characteristics using Fourier analysis tools. |
| CO2 | Describe the fundamental concepts of amplitude modulation and demodulation. |
| CO3 | Articulate different types of modulation schemes and modulated analog signals. |
| CO4 | Perform analysis of noise signals in frequency domain and linear filtering of noise. |
| CO5 | Analyze the performance of FM systems in presence of noise signals. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO7 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Control Systems Engineering | L-T-P | Credits | Marks |
|------|---------------|-----------------------------|-------|---------|-------|
| PC | BTEE-T-PC-005 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of the course is to create an understanding of how modern-day control systems operate along with a thorough knowledge of mathematical modeling and stability analysis. This course also covers fundamentals of state-space methods. |
| Pre-Requisites | Mathematical background of differential equation, Laplace transforms, Basic electrical engineering, Dynamic equations of physical systems are required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Introduction to Control Systems: Concept of control system, Definition, Open Loop / Closed-loop, Feedback, Effect of feedback, Review of complex variables, Laplace Transform, Transfer function and impulse response of linear systems, Concepts of State, State Variables and State-space Model; Block diagram, Signal flow graphs, Signal flow graphs, Mason's Gain formula, Mathematical modelling of dynamical systems using transfer function and state space approaches; Control System Components: Potentiometer, Synchros, AC/DC Servo motors. | 11 Hours |
| Module-2 | Time Response Analysis: Standard Test Signals, Time response of first order systems, Time Response of Second order systems, Type & order of a system, Steady State Errors and Static Error Constants of different types of systems, Effect of adding pole and zero to a system, Design specification of second order system, Performance indices. Introduction to Controllers: Proportional Derivative Error Control (PD Control), Proportional Integral Controller (PI Control), Proportional, Integral and Derivative Controller (PID Control), Derivative Output Control, Tuning Rules for PID controllers (Z-N Tuning). | 8 Hours |
| Module-3 | Concepts of Stability: Necessary conditions for stability, Hurwitz Stability Criterion, Routh Stability Criterion, Relative Stability Analysis; The Root Locus Technique: Introduction, Root locus concepts, Construction of Root locus, Root Contours, Systems with transportation lag. | 8 Hours |
| Module-4 | Stability in Frequency Domain: Mathematical Preliminaries, Frequency Response Analysis: Correlation between Time and Frequency Response, Polar plots; Nyquist Stability Criterion, Assessment of Relative stability using Nyquist Criterion, Closed loop Frequency Response, Bode plots, All Pass and Minimum-Phase Systems. | 9 Hours |

Cont'd...

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-5 | State Variable Analysis: Concept of state, State variable model of dynamic system using physical variable, Phase Variables and Canonical Models, Derivation of Transfer Function, Solution of State Equation, State Transition Matrix, Controllability and Observability, Design of pole placement by state feedback. | 6 Hours |
| Total | | 42 Hours |

Text Books:

- T1. I. J. Nagrath and M. Gopal, *Control Systems Engineering*, 5th Edition, New Age Intl., 2010.
 T2. K. Ogata, *Modern Control Engineering*, 5th Edition, PHI Learning, 2010.

Reference Books:

- R1. B. C. Kuo, *Automatic Control Systems*, 7th Edition, Prentice Hall India, 2010.
 R2. R. C. Dorf and R. H. Bishop, *Modern Control Systems*, 8th Edition, Addison Wesley, 2003.
 R3. U. A. Bakshi and V. U. Bakshi, *Control System Engineering*, 1st Edition, Technical Publications, 2010.

Online Resources:

- <https://nptel.ac.in/courses/108102043/>
- <https://nptel.ac.in/courses/108106098/>
- <https://www.youtube.com/channel/UCq0imsn84ShAe9PBOFnoIrg>: Lectures by Brian Douglas
- <https://ocw.mit.edu/courses/mechanical-engineering/2-04a-systems-and-controls-spring-2013/lecture-notes-labs/>

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

| | |
|-----|--|
| CO1 | Explain and apply basic concepts of control systems to develop mathematical models of various physical systems in engineering and study of feedback characteristics. |
| CO2 | Apply standard test signals to determine performance characteristics of first and second-order systems and understand the design of conventional controllers used in industry to control these performance parameters. |
| CO3 | Classify stability using time domain techniques and analyze a system's performance using the graphical approach. |
| CO4 | Identify the methods of frequency domain analysis and apply it to determine different types of stability in the frequency domain. |
| CO5 | Develop an understanding of state-space approach in various forms to model a system and apply the state feedback method to design a controller using pole-placement. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |

Cont'd...

| | |
|------|---|
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Basics of Power Systems | L-T-P | Credits | Marks |
|------|---------------|-------------------------|-------|---------|-------|
| OE | BTEE-T-OE-032 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to study different aspects of power systems, the complete path of electrical energy from generation up to the consumers, and various components used in operation & control of modern power systems. |
| Pre-Requisites | Knowledge of Basic Electrical Engineering is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on real world examples and case studies. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Generation of Electrical Energy: Basics of electrical generation sources - Thermal, Hydro, Nuclear; their layout, basic components, advantages & disadvantages; Renewable Energy: Wind, Solar; their layout, basic components; Grid connected renewable sources, operational issues. | 8 Hours |
| Module-2 | Transmission Lines & Substations: Components of transmission lines - conductors & supporting structures, insulators, air gaps, and shielding; DC & AC transmission lines, comparison, underground cables, design parameters, benefits of high-voltage transmission; Substation Equipment - transformers, regulators, circuit breakers, isolators, their relationship to system protection, maintenance & system control; digital substation equipment for modernization & reliability. | 9 Hours |
| Module-3 | Distribution System: Primary & secondary, overhead & underground, Consumers - residential, commercial, industrial; voltage classifications, common equipment; modernization & automation, intelligent electronic devices, outage management, customer information systems; Consumption: Wiring to the consumer's load, emergency generators, uninterruptible power supply (UPS), Systems to enhance reliable power service & their operating issues, Smart meters, service reliability indicators, common problems & solutions for large power consumers. | 10 Hours |
| Module-4 | System Protection: System vs. Personal protection, protection against equipment failures, faults on power lines, lightning strikes, inadvertent operations, other causes of system disturbances, Protective relays, Protection against faults, lightning strikes, minimization of major system disturbances; Personal protection & safe working procedures in and around high-voltage power systems; Common safety procedures and methods; Equipotential grounding, Ground potential rise, Touch potential, Step potential; precautions around high-voltage power lines, substations, and around the home. | 8 Hours |

Cont'd...

| Module-# | Topics | Hours |
|--------------|--|-----------------|
| Module-5 | Interconnected Power Systems: Concept of Interconnection, Hierarchical Grid arrangements, Cascade Tripping, Islanding, Load dispatch center, use of SCADA (Supervisory Control and Data Acquisition) and EMS (Energy Management Systems) for reliable operation of large power systems. | 7 Hours |
| Total | | 42 Hours |

Text Books:

- T1. S. W. Blume, *Electric Power System Basics for the Nonelectrical Professional*, 2nd Edition, John Wiley & Sons, 2017.

Reference Books:

- R1. V. K. Mehta and R. Mehta, *Principles of Power Systems*, 4th Edition, S. Chand, 2005.
R2. D. P. Kothari and I. J. Nagrath, *Power System Engineering*, 2nd Edition, McGraw-Hill, 2007.
R3. A. v'Meier, *Electric Power Systems - A Conceptual Introduction*, John Wiley & Sons, 2006. (eBook available at <https://www.personal.psu.edu/sab51/vls/vonmeier.pdf>).

Online Resources:

- <https://nptel.ac.in/courses/108/104/108104052/>: by Dr. S. N. Singh, IIT Kanpur
- <https://nptel.ac.in/courses/108/101/108101040/>: by Dr. A. M. Kulkarni, IIT Bombay

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

| | |
|-----|---|
| CO1 | Describe various renewable & nonrenewable sources of energy for generation of electrical power. |
| CO2 | Explain fundamental aspects of transmission systems and substation equipment. |
| CO3 | Elaborate the components of a distribution systems and transmission of electrical power up to the consumers' premises. |
| CO4 | Develop an understanding of the basics of electrical protection systems in terms of system protection and personal safety. |
| CO5 | Articulate the concepts, advantages and challenges in operation of large interconnected power systems and role of energy management systems(EMS) for reliable operation of large power systems. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |

Cont'd...

| | |
|------|--|
| PO7 | 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. |
| PO8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Applied Linear Algebra | L-T-P | Credits | Marks |
|------|---------------|------------------------|-------|---------|-------|
| OE | BTBS-T-OE-027 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objectives of this course is to gain mathematical maturity by equipping the students to handle computation with matrices, difference equation and similarity transformation for various engineering applications. |
| Pre-Requisites | Knowledge of complex numbers, matrix algebra, and vector space is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Geometry of Linear Equations, Gauss Elimination, Concept of Matrices with Applications, Vector Spaces and Subspaces, Echelon Form, Solution in Matrix Method, L.I, Basis & Dimension, Four Fundamental Subspaces, Linear Transformations. | 9 Hours |
| Module-2 | Orthogonal Vectors & Subspaces, Cosines & Projections onto Lines, Projections & Least Squares, Orthogonal Bases and Gram-Schmidt Process. | 8 Hours |
| Module-3 | Introduction & Properties of Determinants, Formulas for Determinant, Applications of Determinants, Introduction to Eigenvalues & Eigenvectors, Diagonalization of Matrix, Difference Equations, Complex Matrices, Similarity Transformations. | 8 Hours |
| Module-4 | Maxima, Minima & Saddle Points, Tests for Positive Definiteness, Singular Value Decomposition, Minimum Principles. | 8 Hours |
| Module-5 | Introduction to Computations with Matrices, Matrix Norm & Condition Number, Computation of Eigenvalues, Iterative Methods. | 9 Hours |
| Total | | 42 Hours |

Text Books:

T1. G. Strang, *Linear Algebra and Its Applications*, 4th Edition, Cengage Learning, 2007.

Reference Books:

R1. G. Strang, *Introduction to Linear Algebra*, 3rd Edition, Wellesley-Cambridge, 2003.

Online Resources:

1. <https://nptel.ac.in/courses/111/106/111106051/>: by Dr. K. C. Sivakumar, IIT Madras
2. <https://nptel.ac.in/courses/111/102/111102011/>: by Dr. R. K. Sharma and Dr. W. Shukla, IIT Delhi
3. <https://nptel.ac.in/courses/111/108/111108066/>: by Prof. V. Rao, IISc Bangalore
4. <https://nptel.ac.in/courses/111/107/111107106/>: by Prof. P. N. Agrawal and Prof. D. N. Pandey, IIT Roorkee

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

| | |
|-----|--|
| CO1 | Explain and apply matrix methods for solving a system of linear equations. |
| CO2 | Describe orthogonal & projection in vector space and apply it to least square solution. |
| CO3 | Identify and apply Eigen values and Eigen vectors to diagonalization. |
| CO4 | Explain and apply Singular Value Decomposition and to obtain pseudo inverse of a matrix. |
| CO5 | Develop algorithms and write programs to solve linear algebra problems on computers. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Fluid Mechanics | L-T-P | Credits | Marks |
|------|---------------|-----------------|-------|---------|-------|
| OE | BTBS-T-OE-028 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to study the properties and behavior of fluids including fluid statics, kinematics, dynamics, inviscid flow, flow of viscous fluids, measuring instruments and fluid motive devices. |
| Pre-Requisites | Basic knowledge of the material properties of solids, liquids and gases and some knowledge of calculus and differential equations are required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on engineering applications. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Fluid Properties - Density, Specific weight, Specific gravity, Viscosity, Vapor pressure, Compressibility, Pressure at a point, Pascal's law, Pressure variation with temperature, Density & altitude, Simple & differential manometers, Piezometer, Pressure gauges, Hydrostatic forces on submerged surfaces, Forces on horizontal & vertical submerged plane surfaces, Buoyancy & flotation, Archimedes' principle, stability of immersed & floating bodies, Determination of metacentric height. | 10 Hours |
| Module-2 | Kinematics of fluid flow, Acceleration of fluid particles, Lagrangian and Eulerian descriptions, Conservation of mass - continuity equation, Differential equation of continuity, Stream line, Path line, Streak lines & Stream tube, Classification of fluid flow - Steady & unsteady, uniform & non uniform, Laminar & turbulent, Rotational & irrotational, one, two- and three-dimensional flows, Continuity equation in 3D flow, Stream function, Velocity potential function. | 8 Hours |
| Module-3 | Dynamics of Inviscid flows, Surface and body forces, Euler's equation, Bernoulli's equation, Applications - Venturi meter, Orifice meter, Current meter, Pitot tube, Momentum balance equation, Control volume approach, Dynamics of Viscous Fluids; Navier-Stokes equations (explanation only), Navier-Stokes equations in Cartesian form, Application to simple geometries, Couette and Poiseuille flow. | 8 Hours |
| Module-4 | Pipe flow, Friction losses, Moody's diagram and hydraulic diameter, Water level, Velocity and discharge measurements, Notch and weir, Impact of Jet, and relevant equations. | 8 Hours |
| Module-5 | Hydraulic turbines, Impulse turbine - construction and working, Hydraulic turbines, Reaction & Mixed flow turbines - construction and working, Hydraulic pumps, Centrifugal Pumps - construction and working, Hydraulic pumps, Positive Displacement types - construction and working, Principles of Dimensional Analysis and Similarity. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. S. K. Som, G. Biswas, and S. Chakraborty, *An Introduction to Fluid Mechanics and Fluid Machines*, 3rd Edition, McGraw-Hill, 2012.
- T2. E. Rathakrishnan, *Fluid Mechanics - An Introduction*, 3rd Edition, Prentice Hall India, 2012.

Reference Books:

- R1. R. K. Rajput, *Fluid Mechanics and Hydraulic Machines*, 4th Edition, S. Chand Publications, 2008.
- R2. R. K. Bansal, *A Textbook of Fluid Mechanics and Hydraulic Machines*, 9th Edition, Laxmi Publications, 2010.

Online Resources:

1. <https://nptel.ac.in/courses/105/103/105103192/>: by Prof. S. Dutta, IIT Guwahati
2. <https://nptel.ac.in/courses/112/105/112105269/>: by Prof. S. Chakraborty, IIT Kharagpur

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

| | |
|-----|---|
| CO1 | Explain and apply the principles of fluid mechanics to solve problems in hydro-statics. |
| CO2 | Describe the principles of fluid mechanics to solve problems in fluid kinematics. |
| CO3 | Apply the concepts to fluid dynamics for the flow measuring devices. |
| CO4 | Analyze and design free surface and pipe flows for real-world applications. |
| CO5 | Design the working proportions of hydraulic machines. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Operating Systems | L-T-P | Credits | Marks |
|------|---------------|-------------------|-------|---------|-------|
| OE | BTCS-T-OE-036 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to understand the fundamental concepts, techniques & algorithms, and internal working principles of a computer operating system to become a system designer or an efficient application developer. |
| Pre-Requisites | Knowledge of computer programming and data structures is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Introduction: Overview, Evolution of operating system, Types of systems - Batch Processing, Multiprogramming, Time Sharing systems; Personal Computers, Parallel, Distributed, and Real-time Systems; Operating System Services, System components, System calls. | 6 Hours |
| Module-2 | Process Management: Process concepts, states, PCB, Process scheduling queues, queuing diagram, Types of schedulers, Operations on process; Inter-process communication - shared memory, message passing, Concept of buffering, Thread overview, Benefits of multi-threaded program, User and kernel threads, Multi-threading models, Issues with multi-threading - thread cancellation, thread pools, thread specific data; CPU Scheduling: Dispatcher, Scheduling - Criteria, Algorithms - FCFS, SJF, SRTF, RR, Priority, Multi-level Queue (MLQ), MLQ with Feedback. | 10 Hours |
| Module-3 | Process Synchronization: Background, Bounded-buffer – Shared-memory solution to Producer-consumer problem, Race condition, Critical section problem - Peterson's solution, Synchronization hardware: TestAndSet(), swap() instructions, Semaphores - Counting and binary semaphore, spinlocks, Classical problems of synchronization - Bounded-buffer problem, Readers-writers problem, Dining-philosophers problem, Monitors; Deadlock: System model, characterization, Resource-allocation graph, Methods for handling deadlocks, Deadlock prevention & avoidance, Banker's algorithm, Deadlock detection & recovery. | 10 Hours |
| Module-4 | Memory Management: Background, Logical & physical address space, Dynamic loading & dynamic linking, Swapping, Contiguous memory allocation, Dynamic storage allocation problem, Overlays, Paging, Segmentation; Virtual Memory: Background, Demand paging, Page fault, Basic page replacement policy, Page replacement algorithms - FIFO, OPT, LRU, LRU-Approximation, LFU, MFU, Thrashing, Working-set model. | 9 Hours |

Cont'd...

| Module-# | Topics | Hours |
|--------------|--|-----------------|
| Module-5 | Secondary Storage Structure: Overview of mass storage structure, Disk structure, Disk scheduling - FCFS, SSTF, SCAN, C-SCAN, LOOK, C-LOOK, Swap-space management, RAID structure; File System: Concept, Access methods, Directory structure, Directory implementation, Allocation methods, Free space management, Access control list; I/O System: Polling, Interrupts, DMA; Case Studies: The LINUX System. | 7 Hours |
| Total | | 42 Hours |

Text Books:

- T1. A. Silberschatz, P. B. Galvin, and G. Gagne, *Operating System Concepts*, 8th Edition, Wiley, 2009.
 T2. M. Milenković, *Operating Systems: Concepts and Design*, 2nd Edition, Tata McGraw-Hill, 2001.

Reference Books:

- R1. A. S. Tanenbaum, *Modern Operating Systems*, 3rd Edition, PHI, 2009.
 R2. P. B. Prasad, *Operating Systems and System Programming*, 2nd Edition, Scitech Publications, 2015.

Online Resources:

1. <https://nptel.ac.in/courses/106/102/106102132/>: by Prof. S. Bansal, IIT Delhi
2. <https://nptel.ac.in/courses/106/108/106108101/>: by Prof. P. C. P. Bhatt, IISc Bangalore
3. <https://nptel.ac.in/courses/106/106/106106144/>: by Prof. C. Rebeiro, IIT Madras
4. <https://nptel.ac.in/courses/106/105/106105214/>: by Prof. S. Chattopadhyay, IIT Kharagpur
5. <https://www.cse.iitb.ac.in/~mythili/os/>: Notes & slides by Prof. M. Vutukuru, IIT Bombay
6. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-828-operating-system-engineering-fall-2012/lecture-notes-and-readings/>

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

| | |
|-----|--|
| CO1 | Explore principles behind various types of operating systems, system components, system calls, protection mechanisms and services. |
| CO2 | Explain different schedulers, scheduling policies, and design new scheduling algorithms for real life problems. |
| CO3 | Describe the significance of process synchronization through classical synchronization problems and deadlock handling mechanisms. |
| CO4 | Describe the working principle of main memory, cache memory and virtual memory organization and solve memory related problems. |
| CO5 | Articulate secondary storage management, and analyze the performance of various disk scheduling algorithms. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |

Cont'd...

| | |
|------|--|
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Programming in Python | L-T-P | Credits | Marks |
|------|---------------|-----------------------|-------|---------|-------|
| OE | BTCS-T-OE-039 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to study object oriented programming using the Python programming language. Knowledge of Python will be useful for studying Machine Learning, Artificial Intelligence, and Data Science. |
| Pre-Requisites | Basic analytical & logical skill is required for this course. Prior experience with any other programming language will be beneficial. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with programming & problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Introduction to Python: Features of Python, Executing a python program, Interactive and non-Interactive modes, Basic syntax, Data types, Variables, Literals, Input/output statements, Keywords, Identifiers, Operators, Precedence & associativity, Expressions, Control statements. | 8 Hours |
| Module-2 | Arrays, Strings, and Lists: Operations, Slicing, Built-in list function, List comprehension, Tuples - Introduction, Accessing elements, Operations using built-in tuple functions, Dictionaries - Introduction, Accessing values in dictionaries, Built-in dictionary functions, Sets, Function, Recursion; Modules: Creating modules, Import statement, Packages. | 10 Hours |
| Module-3 | Object Oriented Programming: Features, Classes & objects, Creating class & object, Using a class, Methods; Inheritance: Types of inheritance, Overriding methods, Encapsulation & information hiding, Polymorphism, Operator overloading, Method overloading & overriding, Abstract method & class; Exception Handling: Errors, Types of exception, try, except, and finally, assertion. | 9 Hours |
| Module-4 | File Handling: Types of files, Opening & closing, Reading & writing, Binary files; Command line arguments; Database Connectivity: Introduction, Connections, Executing queries, Transactions, SQLDB database connection parameters, Insert, Update, Delete. | 9 Hours |
| Module-5 | Regular Expression: Match function, Search function, Matching vs. Searching, Quantifiers, Pattern; CGI: Introduction, Architecture, CGI environment variables, GET & POST methods, Cookies, File upload; Graphical User Interface: GUI toolkits, Creating GUI widgets with Tkinter, Creating layouts, Radio buttons, Checkboxes, Dialog boxes. | 6 Hours |
| Total | | 42 Hours |

Text Books:

- T1. R. N. Rao, *Core Python Programming*, 2nd Edition, DreamTech Press, 2019.
- T2. P. Barry, *Head First Python*, 2nd Edition, O'Reilly Media, 2010.
- T3. A. Downey, *Think Python*, 2nd Edition, Green Tea Press, 2015.

Reference Books:

- R1. J. Zelle, *Python Programming: An Introduction to Computer Science*, 3rd Edition, Franklin, Beedle & Associates, 2016.
- R2. L. Ramalho, *Fluent Python*, 1st Edition, O'Reilly Media, 2015.
- R3. M. Lutz, *Programming Python*, 4th Edition, O'Reilly Media, 2011.

Online Resources:

1. <https://nptel.ac.in/courses/106/106/106106145/>: by Prof. M. Mukund, IIT Madras
2. <https://help.uis.cam.ac.uk/service/help-support/training/downloads/course-files/programming-student-files/python-courses/>

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

| | |
|-----|--|
| CO1 | Explore Python syntax and use Python flow control to solve simple problems. |
| CO2 | Implement knowledge of functions and different data structures like list, tuple, and dictionary. |
| CO3 | Develop applications using object oriented programming concepts in Python. |
| CO4 | Apply the concept of file handling and database connectivity in real life problems. |
| CO5 | Implement regular expressions and develop GUI based Python applications. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO6 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Biomedical Instrumentation & Signal Processing | L-T-P | Credits | Marks |
|------|---------------|--|-------|---------|-------|
| OE | BTEI-T-OE-020 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to study various biomedical instruments, sensors and signal processing techniques, and their applications in diagnosis, therapeutic and surgical procedures. |
| Pre-Requisites | Knowledge of basic electronics, sensors, and transducers is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on real-world applications. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Introduction to Bioengineering: Sources and examples of biomedical signals, Basic medical Instrumentation system, use of microprocessors, general design constraints; Transducers: Classification, Transducers for Biomedical Applications; Sources of Bio-electric Potentials: Resting and Action Potentials; Anatomy of heart, Different types of Biomedical Signals: ECG, PCG, EEG, EMG. | 9 Hours |
| Module-2 | Biomedical Electrodes and Recorders: Electrode theory, Recording electrodes, Bio-potential Electrodes for ECG, EEG and EMG, Microelectrodes, ECG recorder, Sources of Artifacts in ECG and their removal methods, EEG & EMG recorder. | 8 Hours |
| Module-3 | Patient Care Monitoring: System concepts, Measurement of heart rate, Measurement of pulse rate, Blood pressure and blood flow measurement, Pacemakers and Defibrillators, Electric shock hazards, Leakage currents. | 8 Hours |
| Module-4 | X-Ray and Radioisotope Instrumentation: Generation of Ionizing Radiation, Nature and production of X-Rays, Computed Tomography, Magnetic Resonance Imaging System, Ultrasonic Imaging Systems. | 8 Hours |
| Module-5 | Adaptive Filters: Principle, the steepest descent algorithm, adaptive noise canceller, cancellation of interference in electrocardiography, applications; Canceling Donor heart Adaptive filters, HF noise in ECG, motion artifact in ECG, maternal interference in Fetal ECG, cancellation of maternal ECG, cancellation of ECG signal from electrical activity of chest muscles, cancellation of HF noise in Electro-surgery. | 9 Hours |
| Total | | 42 Hours |

Text Books:

- T1. R. S. Khandpur, *Handbook of Biomedical Instrumentation*, 2nd Edition, McGraw-Hill, 2002.
- T2. D. C. Reddy, *Biomedical Signal processing - Principles & Techniques*, 1st Edition, McGraw-Hill, 2005.
- T3. R. M. Rangayyan, *Biomedical Signal Analysis - A Case Study Approach*, 2nd Edition, John Wiley & Sons, 2002.

Reference Books:

- R1. J. L. Cromwell, F. J. Weibell, and E. A. Pfeiffer, *Biomedical Instrumentation and Measurement*, 2nd Edition, Prentice Hall of India, 2017.
- R2. J. J. Carr and J. M. Brown, *Introduction to Biomedical Equipment Technology*, 4th Edition, Pearson Education, 2000.
- R3. H. E. Thomas, *Handbook of Biomedical Instrumentation and Measurement*, 1st Edition, Reston Publishing Company, 1974.

Online Resources:

1. <https://nptel.ac.in/courses/102101068/>: by Prof. S. Srivastava, IIT Bombay
2. <https://nptel.ac.in/courses/108105101/>: by Prof. S. Mukhopadhyay, IIT Kharagpur
3. <https://ocw.mit.edu/courses/biological-engineering/20-010j-introduction-to-bioengineering-be-010j-spring-2006/videos/>

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

| | |
|-----|--|
| CO1 | Describe the principles and design of biomedical instruments and applications of biomedical engineering. |
| CO2 | Explain design considerations for medical equipment with respect to the human physiological system. |
| CO3 | Describe the principle of operation of various medical recording and imaging systems. |
| CO4 | Identify the elements of risk for different instrumentation methods and basic electrical safety. |
| CO5 | Explain different adaptive methods for biomedical signal processing and noise cancellation. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO7 | 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. |
| PO8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |

Cont'd...

| | |
|------|--|
| PO11 | 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. |
|------|--|

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Universal Human Values & Professional Ethics | L-T-P | Credits | Marks |
|------|---------------|--|-------|---------|-------|
| MC | BTBS-T-MC-020 | | 2-0-0 | 0 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to enable the students to become aware of professional ethics and universal human values. It will instill moral and social values and loyalty to appreciate the rights of others. This course also provides the basis for deciding whether a particular action is morally good or bad. |
| Pre-Requisites | Elementary idea on Psychology, sensitivity to professionalism with respect to morality, judgment, and commitment are required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, and planned interactive sessions. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Introduction to Value Education: Understanding Value Education, Self-exploration as the Process for Value Education, Continuous Happiness and Prosperity – the Basic Human Aspirations, Happiness and Prosperity – Current Scenario, Method to Fulfill the Basic Human Aspirations. | 6 Hours |
| Module-2 | Harmony in the Human Being: Understanding Human being as the Co-existence of the Self and the Body, Distinguishing between the Needs of the Self and the Body, The Body as an Instrument of the Self, Understanding Harmony in the Self, Harmony of the Self with the Body, Programme to ensure self-regulation and Health. | 6 Hours |
| Module-3 | Harmony in the Family and Society: Harmony in the Family – Family as the Basic Unit of Human Interaction, Values in Human-to-Human Relationship, 'Trust' – the Foundational Value in Human Relationship, 'Trust Deficit' – the concept and its dimensions and implications, 'Respect' as the Right Evaluation, Understanding Harmony in the Society, Vision for the Universal Human Order. | 6 Hours |
| Module-4 | Harmony in the Nature or Existence: The Four Orders of Nature, Understanding Harmony in the Nature, Interconnectedness, Self-regulation and Mutual Fulfillment among the Four Orders of Nature, Realizing Existence as Co-existence at all Levels, The Holistic Perception of Harmony in Existence. | 4 Hours |
| Module-5 | Implications of the Holistic Understanding – A Look at Professional Ethics: Natural Acceptance of Human Values, Definitiveness of (Ethical) Human Conduct, A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order, Competence in Professional Ethics, Holistic Technologies, Production Systems and Management Models-Typical Case Studies, Strategies for Transition towards Value-based Life and Profession. | 6 Hours |
| Total | | 28 Hours |

Text Books:

- T1. R. R. Gaur, R. Asthana, and G. P. Bagaria, *A Foundation Course in Human Values and Professional Ethics*, 2nd Edition, Excel Books, 2019.
- T2. A. Nagaraj, *Jeevan Vidya : Ek Parichaya*, Jeevan Vidya Prakashan, 1999.

Reference Books:

- R1. A. N. Tripathi, *Human Values*, 3rd Edition, New Age International Publishers, 2019.
- R2. M. K. Gandhi, Translated by (from Gujarati) M. Desai, *The Story of My Experiments with Truth*, 1st Edition, FingerPrint Publishing, 2009.

Online Resources:

1. <http://hvpe1.blogspot.com/2016/06/notes-human-values-and-professional.html>
2. <https://examupdates.in/professional-ethics-and-human-values>
3. <http://www.storyofstuff.com>
4. <https://aktu.ac.in/hvpe/ResourceVideo.aspx>

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

| | |
|-----|---|
| CO1 | Learn ethical concepts which will enable them to effectively resolve ethical issues in their personal and professional lives. |
| CO2 | Be aware of their duties and responsibilities as professionals towards their organization and society. |
| CO3 | Gather primary knowledge on engineering ethics and its objectives, different parameters of enquiry and engineering as an experiment in society. |
| CO4 | Be conscious about risk and safety while finding a solution to an engineering problem. |
| CO5 | Become attentive of the different global ethical issues. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO3 | 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. |
| PO6 | 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. |
| PO7 | 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. |
| PO8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| PO9 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO10 | 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. |
| PO12 | 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. |

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Digital Signal Processing Lab | L-T-P | Credits | Marks |
|------|---------------|-------------------------------|-------|---------|-------|
| PC | BTEC-P-PC-018 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this laboratory course is to perform signal processing operations like convolution, correlation etc., Frequency analysis and implement FIR & IIR filters in MATLAB. |
| Pre-Requisites | Fundamentals of signals and systems and basics of MATLAB are required. The laboratory experiments shall go along with the topics taught in the theory class. |
| Teaching Scheme | Regular laboratory experiments to be conducted under the supervision of the teacher. Demonstration will be given for each experiment. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|---|
| 1 | Generation of various types of waveforms (sine, cosine, square, triangular etc.) using MATLAB. |
| 2 | Linear convolution of sequences (without using the inbuilt conv. function in MATLAB). |
| 3 | Computation of autocorrelation of a sequence, cross correlation of two sequences using MATLAB. |
| 4 | Computation of the power spectral density of a sequence using MATLAB. |
| 5 | Finding the convolution of a periodic sequence using DFT and IDFT in MATLAB. |
| 6 | Circular convolution of two sequences and comparison of the result with the result obtained from linear convolution using MATLAB. |
| 7 | Convolutions of long duration sequences using overlap add, overlap save using MATLAB. |
| 8 | Implementation of FFT algorithm by decimation in time(DIT) and decimation in Frequency(DIF) using MATLAB. |
| 9 | Design and implementation of FIR (lowpass and highpass) Filters using windowing techniques (rectangular, triangular, and Kaiser) in MATLAB. |
| 10 | Design and implementation of IIR (lowpass and highpass) Filters (Butterworth and Chebyshev) in MATLAB. |

Text Books:

- T1. J. G. Proakis and D. G. Manolakis, *Digital Signal Processing : Principles, Algorithms and Applications*, 4th Edition, Prentice Hall India, 2007.
- T2. A. V. Oppenheim, A. S. Willsky, and S. H. Nawab, *Signals and Systems*, 2nd Edition, Prentice Hall India, 1992.
- T3. S. K. Mitra, *Digital Signal Processing : A Computer Based Approach*, 4th Edition, McGraw Hill, 2013.

Reference Books:

- R1. P. R. Babu, *Digital Signal Processing*, 4th Edition, Scitech Publication, 2011.
- R2. R. Pratap, *Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers*, 7th Edition, Oxford University Press, 2016.

R3. S. S. Kumar and S. V. B. Lenina, *MATLAB: Easy Way of Learning*, PHI Learning, 2016.

R4. A. N. Kani, *Digital Signal Processing*, 2nd Edition, McGraw Hill Education, 2017.

Online Resources:

1. <https://nptel.ac.in/courses/108107115/>: by Prof. Y. V. Hote, IIT Roorkee
2. <https://nptel.ac.in/courses/103106118/>: by Prof. N. Kaisare, IIT Madras

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

| | |
|-----|--|
| CO1 | Explain the generation of various elementary signals in MATLAB. |
| CO2 | Analyze basic signal processing operations like convolution, correlation etc. |
| CO3 | Analyze the spectrum of discrete time signals using DFT. |
| CO4 | Implement various efficient computation technique using FFT-DIT and FFT-DIF algorithm. |
| CO5 | Design FIR and IIR filters using various techniques. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Analog Communication Lab | L-T-P | Credits | Marks |
|------|---------------|--------------------------|-------|---------|-------|
| PC | BTEC-P-PC-009 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this laboratory course is to visualize spectrum of signals, FDM process, modulation schemes, demodulation methods, and simulate through MATLAB & LABVIEW software. |
| Pre-Requisites | Knowledge on Basic Electronics, MATLAB, and LABVIEW are required. |
| Teaching Scheme | Regular laboratory experiments to be conducted using hardware and software tools under the supervision of the teacher; some experiments shall consist of programming assignments. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|--|
| 1 | Analyze and plot the spectrum of following signals with aid of spectrum analyzer: Sine wave, square wave, triangle wave, saw-tooth wave of frequencies 1 KHz, 10KHz, 50KHz, 100KHz and 1 MHz. |
| 2 | Analyze the process of frequency division multiplexing and frequency division demultiplexing. |
| 3 | Study and design of AM modulator and demodulator (Full AM, DSBSC, SSBSC). |
| 4 | Study of FM modulation and Demodulation Techniques. |
| 5 | Observe the process of Pulse Amplitude Modulation and Demodulation. |
| 6 | Study of quantization and PCM technique. |
| 7 | Using MATLAB generate a carrier and a modulating signal, Modulate the carrier using AM, Show the waveform in time domain and analyze its frequency spectrum. Repeat the simulation for modulating signal being square, triangular and other forms of waveform. |
| 8 | Using MATLAB generate a carrier and a modulating signal, Modulate the carrier using FM, Show the waveform in time domain and analyze its frequency spectrum. Repeat the simulation for modulating signal being square, triangular and other forms of waveform. |
| 9 | Using Lab-View software simulates AM modulation and demodulation system. |
| 10 | Using Lab-View software simulate FM modulation and demodulation system. |
| 11 | Design a receiver to demodulate and receive the signal from AM radio station. |
| 12 | Design a receiver to demodulate and receive the signal from the local FM radio station. |

Text Books:

- T1. H. Taub, D. L. Schilling, and G. Saha, *Principles of Communication Systems*, 4th Edition, McGraw-Hill Education, 2013.
- T2. R. P. Singh and S. D. Sapre, *Communication Systems: Analog and Digital*, 3rd Edition, McGraw-Hill Education, 2012.

Reference Books:

- R1. M. Salehi and J. G. Proakis, *Communication System Engineering*, 2nd Edition, PHI, 2002.
- R2. S. Haykin and M. Moher, *Communication Systems*, 5th Edition, John Wiley & Sons, 2009.
- R3. B. P. Lathi, Z. Ding, and H. M. Gupta, *Modern Digital and Analog Communication Systems*, 4th Edition, Oxford University Press, 2017.

Online Resources:

1. <https://nptel.ac.in/courses/117/105/117105143/>: by Prof. G. Das, IIT Kharagpur
2. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/117105143/lec60.pdf
3. <http://www.digimat.in/nptel/courses/video/117105143/L22.html>
4. <http://www.nptelvideos.in/2012/11/communication-engineering.html>

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

| | |
|-----|---|
| CO1 | Investigate the different types of spectrum and analyze their bandwidth. |
| CO2 | Explain the process of FDM and its advantages in the field of communication. |
| CO3 | Describe different analog modulation and their application in transmission and reception. |
| CO4 | Differentiate pulse modulation with respect to their type of generation. |
| CO5 | Represent different analog modulation signals using various software. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Control Systems Engineering Lab | L-T-P | Credits | Marks |
|------|---------------|---------------------------------|-------|---------|-------|
| PC | BTEE-P-PC-006 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of the course is to understand and practice modeling, simulation, and implementation of a physical dynamical system along with an insight to the design of controllers and compensators in modern control system applications. |
| Pre-Requisites | Knowledge of Dynamic equations of physical systems, Basic Electrical Engineering, Laplace Transform, and Matrix Theory is required. |
| Teaching Scheme | Regular laboratory experiments to be conducted using hardware and software tools under the supervision of teachers. Demonstration will be given for each experiment in the pre-lab session. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|---------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|---|
| 1 | Study of Position control system using DC Servo motor and determination of its transfer function. |
| 2 | Study the characteristics of Synchro Transmitter and Receiver. |
| 3 | Observe the time response of a second order process with P, PI and PID controller using process control simulator. |
| 4 | Analyze a 2nd order system by plotting its step response using simulation & programming. |
| 5 | Verify the effect of P, PI, PD and PID Controller of a 2nd order system using simulation & programming. |
| 6 | Study of speed-torque characteristics of two-phase ac servomotor and determination of its transfer function. |
| 7 | Determination of controllability and Observability of a given system using Simulation and programming. |
| 8 | Stability analysis of a given system using time domain and frequency domain plots using Simulation and programming. |
| 9 | Study of frequency response of compensator networks and analysis of system stability with compensator using simulation & programming. |
| 10 | Study the frequency response of lead, lag compensator network. |
| 11 | Study and validate the controllers (ON/OFF and PID) for a temperature control system. |
| 12 | Obtain reduced order model of a higher order system using simulation & programming. |

Text Books:

- T1. I. J. Nagrath and M. Gopal, *Control Systems Engineering*, 5th Edition, New Age Intl., 2010.
 T2. K. Ogata, *Modern Control Engineering*, 5th Edition, PHI Learning, 2010.

Reference Books:

- R1. B. C. Kuo, *Automatic Control Systems*, 7th Edition, Prentice Hall India, 2010.
- R2. R. C. Dorf and R. H. Bishop, *Modern Control Systems*, 8th Edition, Addison Wesley, 2003.
- R3. U. A. Bakshi and V. U. Bakshi, *Control System Engineering*, 1st Edition, Technical Publications, 2010.

Online Resources:

1. <https://nptel.ac.in/courses/108102043/>: by Prof. M. Gopal, IIT Delhi
2. <https://nptel.ac.in/courses/108106098/>: by Prof. P. Ramkrishna, IIT Madras
3. <https://www.youtube.com/channel/UCq0imsn84ShAe9PBOFnoIrg>: Lectures by Brian Douglas
4. <https://ocw.mit.edu/courses/mechanical-engineering/2-04a-systems-and-controls-spring-2013/lecture-notes-labs/>

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

| | |
|-----|---|
| CO1 | Evaluate the parameters and transfer function of various control components and interpret their application in real world. |
| CO2 | Understand the design of compensators and recognize their use for various applications in interdisciplinary domain. |
| CO3 | Classify between linear and non-linear control actions used in a closed loop system and relate the use of appropriate control scheme for industrial applications. |
| CO4 | Differentiate between Transfer Function and State-space representation of any system dynamics using software tools. |
| CO5 | Analyze and compare the performance of first and second order systems in time domain using hardware and software tools. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Corporate Communication Lab | L-T-P | Credits | Marks |
|------|---------------|-----------------------------|-------|---------|-------|
| HS | BTBS-P-HS-012 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|--|
| Objectives | This laboratory course is designed to learn & practice spoken & written corporate communication such as negotiation, persuasion, making presentations, attending meetings, writing reports, proposals etc., and reaching out to clients. |
| Pre-Requisites | Basic knowledge of English grammar and the ability to speak, read and write using the English language. |
| Teaching Scheme | Regular laboratory classes with various tasks designed to facilitate communication through pair work, group/team work, individual and group presentations, discussions, role plays, listening to audios, watching videos, business writing and vocabulary enhancement. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|--|
| 1 | Communication practices in global business settings: coping with organizational barriers – critical analysis. |
| 2 | Persuasive Communication strategies: product launch presentation in teams I. |
| 3 | Persuasive Communication strategies: product launch presentation in teams II. |
| 4 | Negotiation skills: role-plays. |
| 5 | Corporate diction: practice sessions on usage of business jargons and expressions. |
| 6 | Listening practice: business and telephone etiquette. |
| 7 | Meetings and discussions: role-play on business etiquette. |
| 8 | Awareness of Social media etiquette and Writing a Blog: critical analysis of structure, content and style of popular blogs and writing practice. |
| 9 | Report Writing I: recognizing types of business report, assignment on report. |
| 10 | Report Writing II: writing an executive summary and abstract. |
| 11 | Writing a short business proposal. |
| 12 | Understanding e-mail etiquette and writing a professional e-mail. |
| 13 | Reading Comprehension I: note-making and summarizing. |
| 14 | Reading Comprehension II: evaluative comprehension. |

Text Books:

- T1. P. Rath, K. Shalini, and D. Ray, *Corporate Communication*, 1st Edition, Cengage Learning, 2018.
- T2. M. A. Rizvi, *Effective Technical Communication*, 2nd Edition, Tata McGraw-Hill, 2017.
- T3. M. Raman and S. Sharma, *Technical Communication: Principles and Practice*, 3rd Edition, Oxford University Press, 2015.

Reference Books:

- R1. P. A. Argenti and J. Forman, *The Power of Corporate Communication: Crafting the Voice and Image of Your Business*, 1st Edition, Tata McGraw-Hill, 2003.

- R2. S. John, *The Oxford Guide to Writing and Speaking*, 3rd Edition, Oxford University Press, 2013.
 R3. B. K. Mitra, *Effective Technical Communication - A Guide for Scientists and Engineers*, 1st Edition, Oxford University Press, 2006.

Online Resources:

1. <https://archive.nptel.ac.in/courses/109/105/109105144/>: by Prof. S. Singh, IIT Kharagpur
2. <https://archive.nptel.ac.in/courses/109/106/109106129/>: by Dr. Ay. I. Viswamohan, IIT Madras
3. <https://archive.nptel.ac.in/courses/109/104/109104030/>: by Dr. T. Ravichandran, IIT Kanpur
4. <https://www.ef.com/wwen/english-resources/>
5. https://owl.purdue.edu/owl/purdue_owl.html
6. <https://www.usingenglish.com/>
7. <http://www.english-test.net>

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

| | |
|-----|--|
| CO1 | Understand the global work atmosphere and communication barriers in it to be aware of ways to overcome them. |
| CO2 | Develop spoken and written language skills used for business communication. |
| CO3 | Build vocabulary which are commonly used in corporates and be habituated to them. |
| CO4 | Use social media mindfully to maintain business relations. |
| CO5 | Comprehend vital points from business texts skilfully. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO6 | 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. |
| PO8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| PO9 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO10 | 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. |
| PO11 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

Part III

3rd Year B. Tech. (ECE)

Curriculum Structure

| Semester V | | | | | | | | |
|------------|---------------|---|--------------|---|----|------------------|---|---|
| Type | Code | Course Title | WCH L-T-P | | | Credits L-T-P | | |
| THEORY | | | | | | | | |
| HS | BTBS-T-HS-018 | Engineering Economics | 3 | 0 | 0 | 3 | 0 | 0 |
| PC | BTEC-T-PC-014 | Microprocessors & Microcontrollers | 3 | 0 | 0 | 3 | 0 | 0 |
| PC | BTEC-T-PC-006 | Electromagnetic Waves | 3 | 1 | 0 | 3 | 1 | 0 |
| PC | BTEC-T-PC-012 | Digital Communication | 3 | 0 | 0 | 3 | 0 | 0 |
| PE | | Professional Elective - I | 3 | 0 | 0 | 3 | 0 | 0 |
| OE | | Open Elective - II | 3 | 0 | 0 | 3 | 0 | 0 |
| PRACTICAL | | | | | | | | |
| HS | BTBS-P-HS-021 | Soft Skills & Inter-Personal Skills Lab | 0 | 0 | 4 | 0 | 0 | 2 |
| PC | BTEC-P-PC-015 | Microprocessors & Microcontrollers Lab | 0 | 0 | 2 | 0 | 0 | 1 |
| PC | BTEC-P-PC-006 | Electromagnetic Waves Lab | 0 | 0 | 2 | 0 | 0 | 1 |
| PC | BTEC-P-PC-013 | Digital Communication Lab | 0 | 0 | 2 | 0 | 0 | 1 |
| PJ | BTII-P-PJ-002 | Summer Internship - II | 0 | 0 | 0 | 0 | 0 | 1 |
| | | SUB-TOTAL | 18 | 1 | 10 | 18 | 1 | 6 |
| | | TOTAL | 29 | | | 25 | | |

| Semester VI | | | | | | | | |
|-------------|---------------|--------------------------------|--------------|---|----|------------------|---|---|
| Type | Code | Course Title | WCH L-T-P | | | Credits L-T-P | | |
| THEORY | | | | | | | | |
| BS | BTBS-T-BS-014 | Biology for Engineers | 3 | 0 | 0 | 3 | 0 | 0 |
| HS | BTBS-T-HS-022 | Fundamentals of Management | 3 | 0 | 0 | 3 | 0 | 0 |
| PC | BTEI-T-PC-022 | Digital VLSI Design | 3 | 1 | 0 | 3 | 1 | 0 |
| PE | | Professional Elective - II | 3 | 0 | 0 | 3 | 0 | 0 |
| PE | | Professional Elective - III | 3 | 0 | 0 | 3 | 0 | 0 |
| OE | | Open Elective - III | 3 | 0 | 0 | 3 | 0 | 0 |
| PRACTICAL | | | | | | | | |
| PC | BTEC-P-PC-021 | High Frequency Engineering Lab | 0 | 0 | 2 | 0 | 0 | 1 |
| PC | BTEI-P-PC-022 | Digital VLSI Design Lab | 0 | 0 | 4 | 0 | 0 | 2 |
| PJ | BTEC-P-PJ-022 | Skill Lab & Project - I | 0 | 0 | 4 | 0 | 0 | 2 |
| MC | BTBS-P-MC-018 | Yoga / NSS / NCC | 0 | 0 | 2 | 0 | 0 | 0 |
| | | SUB-TOTAL | 18 | 1 | 12 | 18 | 1 | 5 |
| | | TOTAL | 31 | | | 24 | | |

Note: Courses offered under each elective are given in "List of Electives" on Page 121.

List of Electives

| Code | Elective # and Subjects |
|------------------------------------|--|
| Professional Elective - I | |
| BTEI-T-PE-027 | Sensors & Circuit Analysis |
| BTEI-T-PE-007 | Basics of Instrumentation |
| BTEE-T-PE-036 | Soft Computing Techniques |
| BTEC-T-PE-021 | Electronic Devices & Modeling |
| Professional Elective - II | |
| BTEC-T-PE-042 | Information Theory & Coding |
| BTEI-T-PE-024 | IoT & Applications |
| BTEC-T-PE-043 | Robotics & Robot Applications |
| Professional Elective - III | |
| BTEC-T-PE-044 | Digital Image & Video Processing |
| BTEI-T-PE-013 | Analog VLSI Design |
| BTEC-T-PE-046 | Fiber Optic Communications |
| BTEC-T-PE-024 | Microwave Engineering |
| Open Elective - II | |
| BTEE-T-OE-034 | [EEE] Renewable Energy Systems |
| BTBS-T-OE-029 | [BSH] Numerical Optimization |
| BTBS-T-OE-030 | [BSH] Organizational Behaviour |
| BTCS-T-OE-040 | [CSE] Fundamentals of DBMS |
| BTCS-T-OE-045 | [CSE] Algorithm Design & Analysis |
| BTEI-T-OE-019 | [EIE] Industrial Automation & Control |
| Open Elective - III | |
| BTEE-T-OE-033 | [EEE] Power Station Engineering |
| BTBS-T-OE-031 | [BSH] Stochastic Processes |
| BTBS-T-OE-034 | [BSH] Entrepreneurship Development |
| BTCS-T-OE-041 | [CSE] Internet Technology & Applications |
| BTCS-T-OE-042 | [CSE] Advanced Java Programming |
| BTEI-T-OE-021 | [EIE] Virtual Instrumentation |

Note: Open Electives are choice-based courses offered by other departments as indicated within brackets.

| Type | Code | Engineering Economics | L-T-P | Credits | Marks |
|------|---------------|-----------------------|-------|---------|-------|
| HS | BTBS-T-HS-018 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to familiarize the students with elementary principles of economics, provide the tools needed for analyzing time value of money in engineering decision making, profit/revenue data, and make economic analysis for projects and alternatives. |
| Pre-Requisites | Basic knowledge on interest formula and derivatives is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with focus on real-world problem solving. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Engineering Economics-its meaning and importance, Basic problems of an economy. The concept of time value of money; Concept of Interest. Time value of equivalence, Compound interest factors; Cash flow diagrams, Calculation of time value of equivalence, Present worth comparison, Future worth comparison, Pay-back period comparison. | 9 Hours |
| Module-2 | Equivalent annual worth comparison method, Situations for equivalent annual worth comparison, Rate of return, Internal rate of return, Incremental IRR analysis, Depreciation analysis, Methods of depreciation, Straight line method, Declining balance method, SOYD Method and MACRS method of depreciation; After tax comparison, Analysis of public Project, Cost-benefit analysis. | 9 Hours |
| Module-3 | Introduction to Micro Economics and Macro Economics, Theory of demand, Elasticity of demand, Price elasticity of demand, Measurement of elasticity of demand; Income elasticity and cross elasticity of demand, Demand forecasting; Law of supply, Elasticity of supply. | 8 Hours |
| Module-4 | Theory of production, Law of variable proportion, Laws of returns to scale, Cost Concepts, Total Costs, Fixed cost, Variable cost, Revenue concepts, Total revenue, Average revenue and marginal revenue, Market (Forms of market), Perfect Competition, Determination of price under perfect competition, Linear Break-even Analysis. | 8 Hours |
| Module-5 | Inflation, Meaning of inflation, Types, Causes, Measures to control inflation, Commercial Banks, Functions of Commercial Bank, Central bank, Functions of central Bank; National income, Definitions, Concepts of national Income, Methods of measuring National Income. | 8 Hours |
| Total | | 42 Hours |

Text Books:

T1. J. L. Riggs, D. D. Bedworth, and S. U. Randhawa, *Engineering Economics*, 4th Edition, Tata McGraw-Hill, 2004.

T2. H. L. Ahuja, *Principles of Micro Economics*, 16th Edition, S. Chand & Co, 2008.

T3. R. R. Paul, *Monetary Economics*, 11th Edition, Kalyani Publishers, 2015.

Reference Books:

R1. C. S. Park, *Contemporary Engineering Economics*, 6th Edition, Pearson Education, 2015.

R2. D. G. Newnan, T. G. Eschenbach, J. P. Lavelle, and N. A. Lewis, *Engineering Economic Analysis*, 13th Edition, Oxford University Press, 2017.

R3. A. Koutsoyiannis, *Modern Micro Economics*, 2nd Edition, Palgrave Macmillan UK, 2003.

R4. H. C. Petersen, W. C. Lewis, and S. K. Jain, *Managerial Economics*, 4th Edition, Pearson, 2005.

R5. N. G. Mankiw, *Macroeconomics*, 7th Edition, Worth Publishers, 2010.

R6. M. P. Agasty, *Engineering Economics and Costing*, 2nd Edition, Scitech Publication, 2009.

Online Resources:

1. <https://nptel.ac.in/courses/112107209/>: Engineering Economic Analysis

2. https://www.icaai.org/post.html?post_id=10058: Study Materials by ICAI

3. <http://www.icaiknowledgegateway.org/littledms/folder1/chapter-5-part-2.pdf>: National Income Accounting

4. <http://www.m5zn.com/newuploads/2013/05/28/pdf/ed6f3d1f87b9cd2.pdf>: eBook

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

| | |
|-----|---|
| CO1 | Understand the concepts of economics, engineering economics and its application in engineering. |
| CO2 | Solve problems related to engineering economics and analyze decision alternatives in engineering projects. |
| CO3 | Evaluate how changes in demand and supply affect market and production. |
| CO4 | Assess the effects of changes in costs, selling price and units sold on the break-even point and target profit. |
| CO5 | Analyze the macroeconomic environment of the business and its impact on society and enterprise. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO6 | 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. |
| PO7 | 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. |
| PO9 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO11 | 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. |
| PO12 | 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. |

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Microprocessors & Microcontrollers | L-T-P | Credits | Marks |
|------|---------------|------------------------------------|-------|---------|-------|
| PC | BTEC-T-PC-014 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to be familiar about different microprocessors & microcontrollers, be able to develop assembly level programs as per user / industry requirements, and interface with other external devices. |
| Pre-Requisites | Basic knowledge of Digital Electronic Circuits is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on theory and programming activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Introduction: 8085 microprocessor & its organization, General architecture, Bus organization, Memory concepts, Pins and Signals, Timing diagram, Instruction Set & programming, Addressing modes, Memory interfacing, Interrupts. | 10 Hours |
| Module-2 | Intel 8086 Microprocessor: Bus Interface unit, Execution Unit, Register Organization, Memory Segmentation, Pin architecture, Minimum and Maximum mode, Physical Memory Organization, Memory Interfacing, Interrupts, Addressing Modes, Instructions; Advanced Co-processor Architectures – Intel 80386, Pentium. | 8 Hours |
| Module-3 | Interfacing with Peripheral ICs: System level interfacing design with various ICs like 8255 Programmable Peripheral Interface, 8257 DMA Controller, 8259 Programmable Interrupt Controller, 8251 Programmable Communication Interface. | 8 Hours |
| Module-4 | Microcontrollers: 8051 systems – Introduction to 8051 Microcontrollers, Architecture, Memory Organization, Special Function Register, Port Operation, Memory Interfacing, I/O Interfacing, Serial Data Transfer Scheme, On board Communication Interfaces-I2C Bus, SPI Bus, USART, External Communication Interfaces-RS232, USB. | 8 Hours |
| Module-5 | Microcontrollers Programming: 8051 Instruction set, Interrupts, Programming and Applications: Servo motor, Stepper motor control; High Performance RISC Architecture: Introduction to RISC Processors, ARM-Arcon RISC Machine, Core & Architecture, Registers, ARM processor family. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. R. S. Gaonkar, *Microprocessor Architecture, Programming, and Applications with the 8085*, 6th Edition, Penram International Publishing, 2013.
- T2. D. A. Patterson and J. H. Hennessy, *Computer Organization and Design: The Hardware/Software Interface*, 5th Edition, Morgan Kaufman Publishers, 2013.

- T3. A. K. Ray and K. M. Bhurchandani, *Advanced Microprocessors and Peripherals*, 2nd Edition, McGraw Hill Education, 2006.
- T4. M. A. Mazidi, J. G. Mazidi, R. McKinlay, *The 8051 Microcontroller and Embedded Systems: Using Assembly and C*, 2nd Edition, Pearson Education, 2011.
- T5. A. N. Sloss, D. Symes, C. Wright, *ARM System Developer's Guide: Designing and Optimizing System Software*, Elsevier, 2012.

Reference Books:

- R1. K. Kant, *Microprocessors and Microcontrollers: Architecture, Programming and System Design 8085, 8086, 8051, 8096*, 2nd Edition, Prentice Hall India, 2013.
- R2. D. Hall, *Microprocessors and Interfacing*, 3rd Edition, McGraw-Hill Education, 2017.
- R3. K. J. Ayala, *The 8051 Microcontroller*, 3rd Edition, Cengage Learning, 2007.

Online Resources:

1. <https://nptel.ac.in/courses/108107029/>: by Dr. P. Agarwal, IIT Roorkee
2. <https://nptel.ac.in/courses/106108100/>: by Prof. Krishna Kumar IISc Bangalore
3. <http://www.electrical4u.com/circuit-analysis.htm>
4. <http://www.allaboutcircuits.com>
5. <https://www.electronics-tutorials.ws/>

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

| | |
|-----|--|
| CO1 | Describe the architecture & functionality of 8085 Microprocessor, modes of operation & memory management, and develop programs for the same. |
| CO2 | Explain the architecture, programming & memory interfacing of 8086 Microprocessor, virtual memory and co-processor architecture in different advanced processors. |
| CO3 | Interface external devices to the processor like 8255 PPI, 8251 USART, 8279 KeyBoard/display according to user requirements to create products and solutions for real life applications. |
| CO4 | Differentiate the functionality of microprocessor and microcontrollers and program a microcontroller to perform tasks according to the requirements. |
| CO5 | Design, formulate and implement microprocessor and microcontroller based systems using ARM and state of the art tools. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

Cont'd...

| | |
|------|--|
| PO9 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO10 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Electromagnetic Waves | L-T-P | Credits | Marks |
|------|---------------|-----------------------|-------|---------|-------|
| PC | BTEC-T-PC-006 | | 3-1-0 | 4 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to study the fundamentals of electromagnetic waves including coordinate systems, vector calculus, electrostatic fields, magnetostatic fields, Maxwell's Equations, electromagnetic wave propagation, transmission lines, wave guides, and antennas. |
| Pre-Requisites | Basic knowledge of coordinate systems, vector calculus, electric & magnetic fields and related laws is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Coordinate System & Vector Calculus: Cartesian, Cylindrical and Spherical Coordinate Systems; Scalar and Vector Fields; Line, Surface and Volume Integrals, Gradient, Curl, Divergence. | 11 Hours |
| Module-2 | Electrostatic Fields: Coulomb's Law, The Electric Field Intensity, Electric Flux Density and Electric Flux, Gauss's Law, Divergence of Electric Flux Density, The Divergence Theorem, Boundary Conditions in E-Field, Poisson's and Laplace's Equations. Magnetostatic Fields: Ampere's Magnetic Circuital Law and its applications, Stokes' Theorem, Magnetic flux density, Boundary conditions in H-Field. | 11 Hours |
| Module-3 | Time-Varying Fields & Maxwell's Equations: Faraday's Law of Electromagnetic Induction, The Displacement Current, Maxwell's Equations in Differential Form, Maxwell's Equations in Integral Form, Time-varying Potential, The Retarded Potential, Maxwell's Equations for Sinusoidal Variation of Fields with Time. | 11 Hours |
| Module-4 | Electromagnetic Wave Propagation: Wave Propagation in lossy dielectrics, Plane waves in lossless dielectrics, Plane waves in free Space, Plane waves in good conductors, Skin effect, Power and Poynting Vector, Reflection of Plane Wave, Wave Polarization. Transmission Lines: Transmission line parameters, Transmission line equations, Input Impedance, Standing wave ratio, Power, The Smith chart, Applications of transmission line: Quarter wave transformer, Single stub matching. | 11 Hours |
| Module-5 | Waveguides: Rectangular Waveguides, Transverse Magnetic Modes, Transverse Electric modes, Wave propagation in the guide, Power transmission and attenuation. Basic Antennas: Radiation pattern, Beam solid angle, Directivity, Gain, Input impedance, Polarization, Bandwidth, Reciprocity, Effective aperture, Half-wave Dipole, Monopole, Antenna arrays, Linear array. | 12 Hours |
| Total | | 56 Hours |

Text Books:

- T1. M. N. O. Sadiku and S. V. Kulkarni, *Principles of Electromagnetics*, 6th Edition, Oxford University Press, 2015.
- T2. E. C. Jordan and K. G. Balmain, *Electromagnetic Waves and Radiating Systems*, 2nd Edition, Pearson Education, 2009.
- T3. C. A. Balanis, *Antenna Theory: Analysis and Design*, 4th Edition, John Wiley & Sons, 2016.

Reference Books:

- R1. W. H. Hayt and J. Buck, *Engineering Electromagnetic*, 7th Edition, McGraw Hill Education, 2006.
- R2. N. N. Rao, *Fundamentals of Electromagnetics for Engineering*, 1st Edition, Pearson Education, 2009.
- R3. S. Ramo, *Fields and Waves in Communication Electronics*, 3rd Edition, John Wiley & Sons, 2007.
- R4. A. R. Hasish and M. Sachidananda, *Antennas and Wave Propagation*, 1st Edition, Oxford University Press, 2007.

Online Resources:

1. <https://nptel.ac.in/courses/108104087/>: by Prof. P. Kumar, IIT Kharagpur
2. <https://nptel.ac.in/courses/108/106/108106152/>: by Prof. U. Khankhoje, IIT Madras
3. <https://nptel.ac.in/courses/108/104/108104130/>: by Prof. P. Kumar, IIT Kanpur
4. <https://nptel.ac.in/courses/108/102/108102119/>: by Prof. S. Aditya, IIT Delhi
5. <https://nptel.ac.in/courses/108/101/108101090/>: by Prof. K. Sankaran, IIT Bombay
6. <https://nptel.ac.in/courses/108/101/108101092/>: by Prof. G. Kumar, IIT Bombay

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

| | |
|-----|--|
| CO1 | Explain various coordinate systems and vector calculus. |
| CO2 | Simulate the behaviour of electrostatic & magnetostatic fields. |
| CO3 | Describe time-varying fields and Maxwell's equations on electromagnetics. |
| CO4 | Explain electromagnetic wave propagation through dielectrics, space, and transmission lines. |
| CO5 | Articulate EM wave propagation in wave guides and fundamentals of antennas. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Digital Communication | L-T-P | Credits | Marks |
|------|---------------|-----------------------|-------|---------|-------|
| PC | BTEC-T-PC-012 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to study the concepts of digital communication systems covering sampling, aliasing, signal distortion, and different techniques used for waveform coding. |
| Pre-Requisites | Basics of analog communication and probability & statistics is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Digital Communication Systems: Signal source, Line coder, Multiplexer, Regenerative repeater, Sampling of multiple band-limited signals, Signal reconstruction, Quantization of signals (uniform & non-uniform), PCM system, Companding, μ -law and A-law compression, Input-output characteristics, T1 digital system, Multiplexing T1 lines - The T2, T3 and T4 lines, Line Coding, DPCM, DM and ADM. | 9 Hours |
| Module-2 | Noise in PCM and DM: Quantization noise, Output signal power, Thermal noise, Output SNR in PCM, Quantization noise in Delta Modulation, Output signal power, Output SNR, Comparison with PCM and DM; Digital Modulation Techniques: Concept of geometric interpretation of signals, Schwarz's inequality, Concepts of orthogonality and orthonormality, Generation, Transmission, Reception, Spectrum, Geometrical representation and probability of symbol error of ASK, BPSK, DPSK, QPSK, QAM, M-ary PSK, BFSK, M-ary FSK, and Minimum Shifting Keying (MSK). | 9 Hours |
| Module-3 | Signal Detection: A base band signal receiver, Peak signal to RMS noise output voltage ratio, Probability of error, Optimum threshold, Optimum receiver (base band & pass band), Optimum filter transfer function, Optimum filter realization using Matched filter, Probability error of the matched filter, Optimum filter realization using correlator and ML Detector. | 8 Hours |
| Module-4 | Principle of Digital Data Transmission: Line Coding - PSD of various line codes, Polar signaling, Constructing a DC Null in PSD by pulse shaping, On Off signaling, Bipolar signaling; Pulse shaping – ISI and effect, Nyquist criterion for zero ISI; Scrambling, Digital receiver, Equalizers, Timing extraction, Detection error and Eye Diagram. | 8 Hours |
| Module-5 | Multiple Access Techniques: FDMA, TDMA, CDMA, OFDM, OFDM transmitter and receiver, Orthogonality of sub-carriers, Concept of cyclic prefix, OFDM block-diagram, MIMO system, MIMO system solutions, MIMO system model, MIMO capacity on Fading channels. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. H. Taub, D. L. Schilling, and G. Saha, *Principles of Communication Systems*, 4th Edition, McGraw Hill Education, 2013.
- T2. B. P. Lathi and Z. Ding, *Modern Digital and Analog Communication Systems*, 4th Edition, Oxford University Press, 2010.
- T3. S. Haykin, *An Introduction to Analog and Digital Communications*, 2nd Edition, John Wiley & Sons, 2007.

Reference Books:

- R1. L. W. Couch II, *Digital and Analog Communication Systems*, 8th Edition, Pearson Education, 2013.
- R2. B. Sklar, *Digital Communication - Fundamentals and Applications*, 2nd Edition, Pearson Education, 2009.

Online Resources:

1. <https://nptel.ac.in/courses/108/102/108102096/>: by Prof. S. Prasad, IIT Delhi
2. <https://nptel.ac.in/courses/108/101/108101113/>: by Prof. S. N. Merchant, IIT Bombay
3. <https://nptel.ac.in/courses/108/102/108102120/>: by Prof. A. Dixit, IIT Delhi

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

| | |
|-----|--|
| CO1 | Explain the sampling theorem, practical issues related to sampling, signal reconstruction, quantization, encoding along with applications. |
| CO2 | Apply digital modulation & demodulation techniques considering bandwidth, SNR and power spectral efficiency. |
| CO3 | Design optimum receivers for pass band and base band communications and compare the performance of correlator receiver with matched filter reception. |
| CO4 | Visualize practical issues related to digital data transmissions such as pulse shaping, line coding, repeater circuits, equalizer and timing extraction. |
| CO5 | Describe different types of multiple access techniques, OFDM transmission and reception along with MIMO System. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

Cont'd...

| | |
|------|--|
| PO6 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Sensors & Circuit Analysis | L-T-P | Credits | Marks |
|------|---------------|----------------------------|-------|---------|-------|
| PE | BTEI-T-PE-027 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to study the characteristics of different types of measurement systems and principles & applications of various sensing elements. |
| Pre-Requisites | Basic knowledge of physics, mathematics, electrical, and electronics is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on real world examples & case studies. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Introduction: Basics and functional elements of measurement systems, Types of instruments and applications; Active/passive transducers, Analog/digital mode of operation; Static Characteristics: Systematic characteristics, Statistical characteristics, Calibration; Resistive Sensors: Potentiometers, RTD, Thermistor, Strain Gauge. | 8 Hours |
| Module-2 | Capacitive Sensing Elements: Variable separation, Area and dielectric, Sensors for pressure, humidity, and level measurement; Inductive Sensing Elements: Variable reluctance and LVDT; Hall effect sensors, Temperature Sensors: Thermocouples, IC temperature sensors, Radiation pyrometer (Narrow Band & Broad Band), Optical pyrometer. | 8 Hours |
| Module-3 | Motion Sensor: Types of motion, Principles & types of accelerometers; Circuit Analysis and Applications: Steady-state acceleration, Vibration and shock; Piezoelectric accelerometers and signal conditioning; Optical Detectors: Photodiodes, Circuit analysis; Miscellaneous Sensors: Ultrasonic, IR, PIR, Microwave radar. | 8 Hours |
| Module-4 | Analog Circuit Analysis: Introduction, Principle of analog signal conditioning, Linearization, Conversions, Zero, and span adjustment, Level changing, AC/DC power supply, Filtering and impedance matching, Passive circuits, Divider circuit, Bridge circuits, Operational Amplifier Circuits: Voltage follower, Inverting & non-inverting circuits, Differential amplifier, Integrator, Differentiator, Instrumentation amplifier; Case study: Relay driver circuits, Voltage-to-current converter, Current-to-voltage converter, AC carrier system. | 10 Hours |
| Module-5 | Digital Circuit Analysis: Comparators, DAC (bipolar, resolution, characteristics), ADC (bipolar, characteristics, Conversion time, Sample-hold, Microprocessor compatible), Frequency-based converters; Data Presentation Elements: Light-emitting diode (LED) displays, Liquid crystal displays (LCDs); Case study: Digital pH meter, Digital tachometer, Fully automatic digital instrument, Digital capacitance meter, Microprocessor-based instruments, IEEE 488 bus. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. C. D. Johnson, *Process Control Instrumentation Technology*, 8th Edition, Pearson Education, 2014.
 T2. J. P. Bentley, *Principles of Measurement Systems*, 4th Edition, Pearson Education, 2005.
 T3. H. S. Kalsi, *Electronics Instrumentation & Measurements*, 4th Edition, McGraw-Hill Education, 2019.

Reference Books:

- R1. A. K. Sawhney, *A Course in Electrical and Electronics Measurements & Instrumentation*, 1st Edition, Dhanpat Rai & Co., 2015.
 R2. E. O. Doebelin, *Measurement Systems - Applications and Design*, 6th Edition, McGraw Hill, 2007.
 R3. C. Rangan, G. Sarma, and V. S. V. Mani, *Instrumentation : Devices and Systems*, 2nd Edition, McGraw Hill, 2017.

Online Resources:

1. <https://nptel.ac.in/courses/108/108/108108147/>: By Prof. H. J. Pandya, IISc Bangalore
2. <https://nptel.ac.in/courses/115107122/>: By Prof. S. K. Srivastava, IIT Roorkee
3. <https://nptel.ac.in/courses/117108038/>: By Prof. M. K. Gunasekaran, IISc Bangalore

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

| | |
|-----|---|
| CO1 | Describe the performance characteristics of measuring instruments and correlate them with resistive-type sensors. |
| CO2 | Explain the principles of capacitive, inductive, and optical sensing elements. |
| CO3 | Identify and utilize various motion sensors used in industrial applications. |
| CO4 | Investigate the design of analog signal conversion circuits in various sensing systems using case studies. |
| CO5 | Investigate the design of digital signal conversion circuits in various sensing systems using case studies. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

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Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Basics of Instrumentation | L-T-P | Credits | Marks |
|------|---------------|---------------------------|-------|---------|-------|
| PE | BTEI-T-PE-007 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to introduce the basic principles & uses of different electrical & electronic measuring instruments including applications of transducers, storage, display and data acquisition systems. |
| Pre-Requisites | Basic knowledge of intermediate physics, Mathematics, Basic Electrical Engineering and Basic Electronics Engineering is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Qualities of Measurement: Significance of measurement, functional elements of generalized measurement systems, deflection & null type instruments, analog/digital mode of operation; Static & Dynamic Characteristics: Systematic and statistical characteristics, calibration; Errors in Measurement: types of error, normal distribution of errors, and concept of calibration and loading effects of series and shunt connected instruments. | 9 Hours |
| Module-2 | Bridge Circuits: DC and AC Bridges, Errors in bridge circuits, Quality factor (Q) and dissipation factor (D), General equations for bridge balance; Application of DC and AC bridges: Resistance measurement (low, medium, and high resistance), Insulation resistance measurement, Inductance measurement (Maxwell's, Hay's, and Anderson bridge) and Capacitance measurement (Wien's, Owens's and Schering Bridge). | 9 Hours |
| Module-3 | Measuring Instruments: DC galvanometer, DC Potentiometer, PMMC and MI instruments, voltmeters, ammeters, ohmmeters and extension of the range of instruments, AC indicating instruments: EDM Wattmeter (1-phase & 3-phase), Energy meter; Basics of instrument transformer, Digital CRO, DVM, Digital frequency meter and Spectrum Analyzer. | 9 Hours |
| Module-4 | Basic Sensing Elements: Sensors, Transducers and its classification & selection of transducers; Resistive sensing elements: Resistive potentiometers, strain gauges, RTD, and Thermistor; Inductive Sensing Elements: Principle, inductive displacement sensor, push-pull type, Variable reluctance displacement sensor, LVDT, RVDT, Hall effect sensors. | 8 Hours |
| Module-5 | Capacitive Transducers: Variable separation, area & dielectric displacement transducer, push-pull type capacitive sensor, pressure, humidity, and level measurement. | 7 Hours |
| Total | | 42 Hours |

Text Books:

- T1. E. W. Golding and F. C. Widdis, *Electrical Measurements and Measuring Instruments*, 5th Edition, Reem Publication, 2015.

- T2. A. K. Ghosh, *Introduction to Measurement and Instrumentation*, 3rd Edition, PHI Learning, 2009.
 T3. H. S. Kalsi, *Electronic Instrumentation and Measurements*, 4th Edition, McGraw-Hill Education, 2019.
 T4. A. K. Sawhney, *A Course in Electrical and Electronics Measurements & Instrumentation*, Dhanpat Rai & Co, 2015.

Reference Books:

- R1. J. J. Carr, *Elements of Electronics Instrumentation Measurement*, 3rd Edition, Pearson Education, 2003.
 R2. D. A. Bell, *Electronic Instrumentation and Measurements*, 3rd Edition, Oxford University Press, 2013.
 R3. J. P. Bentley, *Principles of Measurement Systems*, 4th Edition, Pearson Education, 2005.
 R4. D. V. S. Murthy, *Transducers and Instrumentation*, 2nd Edition, PHI Learning, 2008.

Online Resources:

1. <https://nptel.ac.in/courses/108/105/108105153/>: by Prof. A. Chatterjee, IIT Kharagpur
2. <https://nptel.ac.in/courses/108/105/108105062/>: by Prof. S. Mukhopadhyay and Prof. S. Sen, IIT Kharagpur
3. <https://nptel.ac.in/courses/108/105/108105064/>: by Prof. A. Barua, IIT Kharagpur

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

| | |
|-----|--|
| CO1 | Explain the characteristics, errors, and calibration concepts of different measuring instruments. |
| CO2 | Evaluate the values of R, L, and C using suitable bridges and their applications. |
| CO3 | Analyze the construction, characteristics, and working principles of various measuring instruments. |
| CO4 | Explain the construction, characteristics, and working principles of different sensing elements used in different measuring instruments. |
| CO5 | Explore the concepts of capacitive transducers and their applications in modern industrial instrumentation. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO6 | 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. |

Cont'd...

| | |
|------|--|
| PO7 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Soft Computing Techniques | L-T-P | Credits | Marks |
|------|---------------|---------------------------|-------|---------|-------|
| PE | BTEE-T-PE-036 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to study numerical methods and various techniques used in soft computing to formulate approximate models and find solutions to complex real-life problems. |
| Pre-Requisites | Basic knowledge of matrix, numerical methods, interpolation, integration and differentiation is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Basic Tools of Soft Computing: Evolution of Computing - Soft Computing constituents, Difference between soft computing and hard computing, Fuzzy logic, Basics of fuzzy logic theory, Crisp and fuzzy sets, Biological background of Neural Networks and its architecture, Basics of Genetic Algorithm and Particle Swarm Optimization, Characteristics of Soft computing and its applications. | 7 Hours |
| Module-2 | Fuzzy Logic Systems: Operations on Fuzzy Sets, Membership Functions, Fuzzy relations, Fuzzy rules, Propositions, Implications and inferences, Zadeh's compositional rule of inference, Methods of Defuzzification. Fuzzy Logic Controller: Fuzzy Inference System, Mamdani, Takagi and Sugeno architectures, Examples and applications of fuzzy logic controller. Introduction to fuzzy PI and fuzzy PID control. | 12 Hours |
| Module-3 | Artificial Neural Networks: Neural network architectures, Single layer feed forward network, Multi-layer feed forward network, Recurrent networks; Early neural network architectures - Rosenblatt's Perceptron, ADALINE network, MADALINE network, Examples and applications of neural networks. | 7 Hours |
| Module-4 | Training of ANN: Back propagation algorithm, Effect of tuning parameters of the back propagation algorithm; Radial Basis Function networks & Least Square training algorithm; Kohonen self-organizing map and learning vector quantization networks; Recurrent neural networks, Simulated annealing neural networks; Adaptive Neuro-fuzzy inference systems (ANFIS) | 10 Hours |
| Module-5 | Evolutionary Computing: Concept of Genetics, GA architectures, GA operators- Encoding, Crossover, Selection, Mutation Introduction to other optimization techniques and hybrid evolutionary algorithms. | 6 Hours |
| Total | | 42 Hours |

Text Books:

- T1. J. S. R. Jang, C. T. Sun, and E. Mizutani, *Neuro-Fuzzy & Soft Computing - A Computational Approach to Learning and Machine Intelligence*, 1st Edition, PHI Learning, 2015.

- T2. S. Rajasekaran and G. A. V. Pai, *Neural Networks, Fuzzy Systems and Evolutionary Algorithms : Synthesis and Applications*, 2nd Revised Edition, PHI Learning, 2017.

Reference Books:

- R1. F. O. Karray and C. De Silva, *Soft Computing and Intelligent Systems Design - Theory, Tools and Applications*, 1st Edition, Pearson Education, 2009.
 R2. S. Haykin, *Neural Networks : A Comprehensive Foundation*, 2nd Edition, Pearson Education, 1997.
 R3. T. J. Ross, *Fuzzy Logic with Engineering Applications*, 3rd Edition, Wiley, 2011.

Online Resources:

1. <https://nptel.ac.in/courses/127/105/127105006/>: by Prof. D. K. Pratihari, IIT Kharagpur
2. <https://nptel.ac.in/courses/106/105/106105173/>: Prof. D. Samanta, IIT Kharagpur
3. <https://nptel.ac.in/courses/117/105/117105084/>: Prof. S. Sengupta, IIT Kharagpur

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

| | |
|-----|---|
| CO1 | Get an understanding of different soft computing techniques and their applicability. |
| CO2 | Gain insight on fuzzy principles & inference and their implementation in designing fuzzy systems. |
| CO3 | Apply different types of neural networks in electrical & electronics engineering problems. |
| CO4 | Analyze effectiveness of neural networks for solving complex engineering problems. |
| CO5 | Develop knowledge about evolutionary computation with focus on genetic algorithm. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Electronic Devices & Modeling | L-T-P | Credits | Marks |
|------|---------------|-------------------------------|-------|---------|-------|
| PE | BTEC-T-PE-021 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to study electronic devices to evaluate & extract their model parameters and modeling of diode, Bipolar Junction Transistor, Metal-Oxide-Semiconductor Transistor and LASER. |
| Pre-Requisites | Basic knowledge of Semiconductor material, Electronics device and circuits is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | PN-Junction Diode and Schottky Diode: DC Current-Voltage Characteristics, Static Model, Large-Signal Model, Small-Signal Model, Schottky Diode and its Implementation in SPICE2, Temperature and Area Effects on the Diode Model Parameters, SPICE3, HSPICE and PSPICE Models. | 8 Hours |
| Module-2 | Bipolar Junction Transistor (BJT): Transistor Conversions and Symbols, EbersMoll Static Model, Ebers-Moll Large-Signal Model, Ebers-Moll Small-Signal Model, Gummel-Poon Static Model, Gummel-Poon Large-Signal Model, Gummel-Poon Small-Signal Model, Temperature and Area Effects on the BJT Model Parameters, Power BJT Model, SPICE3, HSPICE and PSPICE Models. | 9 Hours |
| Module-3 | Metal-Oxide-Semiconductor Transistor (MOST): Structure and Operating Regions of the MOST, LEVEL1 Static Model, LEVEL2 Static Model, LEVEL1 and LEVEL2 Large-Signal Model, LEVEL3 Static Model, LEVEL3 Large-Signal Model, The Effect of Series Resistances, Small-Signal Models, The Effect of Temperature. | 9 Hours |
| Module-4 | BJT Parameter Measurements: Input and Model Parameters, Parameter Measurements. MOST Parameter Measurements: LEVEL1 Model Parameters, LEVEL2 Model (Long-Channel) Parameters, LEVEL2 Model (Short-Channel) Parameters, LEVEL3 Model Parameters, and Measurements of Capacitance. | 8 Hours |
| Module-5 | Modeling of LASER Diode: Rate equations, Numerical schemes: Small signal modeling and Large signal modeling, Equivalent circuits. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. G. Massobrio and P. Antognetti, *Semiconductor Device Modeling with SPICE*, 2nd Edition, McGraw-Hill Education, 2010.
- T2. D. K. Schroder, *Semiconductor Material and Device Characterization*, 3rd Edition, John Wiley & Sons, 2006.

Reference Books:

- R1. R. S. Muller, T. I. Kamins, and M. Chan, *Device Electronics for Integrated Circuits*, 3rd Edition, John Wiley & Sons, 2003.
- R2. H. C. Casey, *Devices for Integrated Circuits : Silicon and III-V Compound Semiconductors*, 1st Edition, John Wiley & Sons, 1999.

Online Resources:

1. <https://nptel.ac.in/courses/117106033/>: by Prof. S. Karmalkar, IIT Madras
2. <https://nptel.ac.in/courses/117/101/117101058/>: by Prof. A. N. Chandorkar, IIT Bombay
3. [https://nptel.ac.in/content/storage2/courses/108105066/PDF/L-6\(DK\)\(PE\)%20\(\(EE\)NPTEL\).pdf](https://nptel.ac.in/content/storage2/courses/108105066/PDF/L-6(DK)(PE)%20((EE)NPTEL).pdf)

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

| | |
|-----|---|
| CO1 | Understand, extract and implement the static characteristics of Diode including the effect of temperature and area on the Diode Model Parameters. |
| CO2 | Understand, extract and implement the static characteristics of BJT including the effect of temperature and area on the BJT Parameters. |
| CO3 | Formulate the structural behavior of MOSFET with their LEVELs and analyze its effect on series resistances, Small-Signal models & temperature. |
| CO4 | Evaluate and extract the Model parameters of different LEVELs of BJT and MOSFET before implementation in industry. |
| CO5 | Formulate the structural behavior of optoelectronic device LASER, Small-Signal models and Large signal model. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO7 | 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. |

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Renewable Energy Systems | L-T-P | Credits | Marks |
|------|---------------|--------------------------|-------|---------|-------|
| OE | BTEE-T-OE-034 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to study various types of renewable energy sources, the technologies for generation, storage, and proper utilization of renewable energy. |
| Pre-Requisites | Basic knowledge on semiconductor physics, fluid dynamics and electrical machines is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as needed, sessions are planned to be interactive with focus on real world examples and case-studies. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Introduction: Conventional & non-conventional energy sources, their impact, availability, variability, Indian and world scenario; Solar, Wind, Biomass, Wave, Tidal, Geothermal energy systems; Solar Energy: Solar processes, Composition of solar radiation; Extra-terrestrial & terrestrial radiation, Angles - Azimuth, Zenith, Hour; Irradiance, Solar constant; Solar Thermal Systems & Applications: Solar collectors, Types & performance characteristics, Water heating systems (active & passive), Space heating & cooling systems, Desalination systems, Solar cooker, Solar thermal power plant. | 8 Hours |
| Module-2 | Solar Photovoltaic System: Operating principle, Photovoltaic cell concepts, Cell, Module, Array, Losses in solar cell, Effects of partial & complete shadowing, Series and parallel connections, Cell mismatching, PV voltage-current characteristics, Equivalent circuit, Maximum power point tracking; Applications: battery charging, Pumping, Lighting, Peltier cooling. | 10 Hours |
| Module-3 | Biomass Power: Principles of biomass conversion, Combustion and fermentation, Anaerobic digestion, Types of biogas digester, Wood gasifier, Pyrolysis, Applications, Biogas, Wood stoves, Bio diesel, Combustion engine, Urban waste to energy conversion, Biomass based power generation. | 9 Hours |
| Module-4 | Wind Energy: Wind energy, Variability, Conversion principle; Wind power density, Efficiency limit, Types of converters, Aerodynamics of rotors, Power~Speed and Torque~Speed characteristics, Wind turbine control systems; Conversion to Electrical Power: Induction and synchronous generators, Grid connected & self excited induction generator operation, Constant voltage & constant frequency generation with power electronic control, Single & double output systems, Reactive power compensation, Characteristics of wind power plant, Concepts of DFIG. | 10 Hours |

Cont'd...

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-5 | Energy Storage Systems: Batteries, Ultra capacitors, SMES; Fuel Cell: Fuel Cell Basics, History of fuel cell technology, Open circuit voltage, Nernst equation analysis, Causes for voltage loss, Types of fuel cell and their efficiency, Applications; Introduction to Hybrid Energy Systems: PV-Wind, PV-Fuel Cell, PV-Diesel. | 5 Hours |
| Total | | 42 Hours |

Text Books:

- T1. G. Boyel, *Renewable Energy - Power for a Sustainable Future*, 3rd Edition, Oxford University Press, 2012.
- T2. B. H. Khan, *Non-Conventional Energy Resources*, 3rd Edition, McGraw Hill Education, 2017.
- T3. S. N. Bhadr, D. Kastha, and S. Banerjee, *Wind Electrical Systems*, 7th Edition, Oxford University Press, 2005.

Reference Books:

- R1. S. A. Abbasi and N. Abbasi, *Renewable Energy Sources and Their Environmental Impact*, 1st Edition, PHI Learning, 2004.
- R2. S. H. Saeed and D. K. Sharma, *Non-Conventional Energy Resources*, 4th Edition, S. K. Kataria & Sons, 2019.
- R3. S. Peake, *Renewable Energy : Power for a Sustainable Future*, 4th Edition, Oxford University Press, 2018.

Online Resources:

1. <https://nptel.ac.in/courses/103/107/103107157/>: by Prof. B. Mondal, IIT Roorkee
2. <https://nptel.ac.in/courses/108/105/108105058/>: by Prof. S. Banerjee, IIT Kharagpur
3. <https://nptel.ac.in/courses/121/106/121106014/>: by Dr. P. Haridoss, IIT Madras

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

| | |
|-----|---|
| CO1 | Generalize solar thermal systems and identify various alternate energy sources & their characteristics. |
| CO2 | Analyse and design a solar photovoltaic system for specified applications. |
| CO3 | Evaluate the effectiveness of biomass energy conversion in waste management. |
| CO4 | Design wind energy systems and analyze their operational characteristics. |
| CO5 | Investigate the operation of fuel cell and configuration of different hybrid energy systems. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |

Cont'd...

| | |
|------|--|
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO7 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Numerical Optimization | L-T-P | Credits | Marks |
|------|---------------|------------------------|-------|---------|-------|
| OE | BTBS-T-OE-029 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objectives of this course is to gain mathematical maturity by equipping the students to handle the linear and non linear problems of optimization in different fields of engineering. |
| Pre-Requisites | Knowledge of coordinate geometry, calculus and matrix algebra is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Linear Programming: Graphical Method, Simplex Method, Methods of Artificial Variables, Alternate Optima, Redundancy & Degeneracy. | 8 Hours |
| Module-2 | Mathematics of Simplex Method (without proof), the Revised Simplex Method, Dual Problem, Construction of Dual, Duality Theorem (without proof), Dual Simplex Method, Post Optimal analysis. | 9 Hours |
| Module-3 | Integer Linear Programming: Gomory's cutting Plane Method for All Integer & Mixed Integer Programming, Branch & Bound Method, Convex Function, Convex Programming Problem, Quadratic Programming and Wolfe's Method. | 8 Hours |
| Module-4 | Optimality Conditions, Lagrangian & Lagrange Multipliers, KKT Necessary/Sufficient Optimality Conditions, Duality in Non-linear Programming, Unconstrained Optimization: Line Search Methods for Unimodal Functions, Steepest Descent Method, Newton's Method, Modified Newton's Method, Conjugate Gradient Method. | 9 Hours |
| Module-5 | Introduction to computations with matrices, Matrix norm & condition number, computation of Eigen values, Iterative methods. | 9 Hours |
| Total | | 42 Hours |

Text Books:

- T1. S. Chandra, Jayadeva, and A. Mehera, *Numerical Optimization with Applications*, 1st Edition, Narosa Publisher, 2013.

Reference Books:

- R1. D. G. Luenberger and Y. Ye, *Linear & Nonlinear Programming*, 1st Edition, Springer, 2016.
 R2. S. S. Rao, *Engineering Optimization - Theory and Practice*, 4th Edition, John Wiley & Sons, 2013.
 R3. K. Dev, *Optimization for Engineering Design - Algorithms and Examples*, 2nd Edition, PHI, 2012.

Online Resources:

1. <https://nptel.ac.in/courses/106108056/>: Dr. S. K. Shevade, IISc Bangalore

P.T.O

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

| | |
|-----|---|
| CO1 | Apply simplex method to solve linear programming problems. |
| CO2 | Explain the concepts behind simplex method and apply it to sensitivity analysis. |
| CO3 | Apply integer programming and convex programming methods in optimization problems. |
| CO4 | Explain the concepts and conditions of non-linear programming problems and its application. |
| CO5 | Solve constrained optimization problems by applying advanced optimization techniques. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Organizational Behaviour | L-T-P | Credits | Marks |
|------|---------------|--------------------------|-------|---------|-------|
| OE | BTBS-T-OE-030 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to understand the human interactions in an organization and develop the skills for leadership, conflict resolution and take rational decisions to attain business goals. |
| Pre-Requisites | General knowledge of any organization and its operations is sufficient. |
| Teaching Scheme | Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with real-life examples. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Organizational Behaviour (OB): Definition & Meaning, Importance; Learning: Nature, Learning Cycle, Components, Theories; Personality: Meaning & Definition, Determinants of Personality, Personality Traits, Personality and OB. | 9 Hours |
| Module-2 | Perception: Meaning & Definition, Perceptual Process, Importance of Perception in OB; Motivation: Nature & Importance, Herzberg's Two Factor Theory, Maslow's Need Hierarchy Theory, Alderfer's ERG Theory. | 8 Hours |
| Module-3 | Organizational Behaviour Process: Communication - Importance, Types, Gateways, Barriers, Communication as a tool for improving Interpersonal Effectiveness; Groups in Organizations: Nature, Types, Group Cohesiveness, Group Decision-making, Managerial Implications, Effective Team Building; Leadership: Leadership & Management, Theories of Leadership; Conflict: Nature of Conflict and Conflict Resolution. | 9 Hours |
| Module-4 | Organizational Culture: Meaning & Definition, Culture and Organizational Effectiveness; Introduction to Human Resource Management: Selection, Orientation, Training and Development, Performance Appraisal. | 8 Hours |
| Module-5 | Organizational Change: Importance of Change, Planned Change and OB techniques; International Organizational Behavior: Trends in International Business, Cultural Differences and Similarities, Individual and Interpersonal Behavior in Global Perspective. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. K. Davis, *Organisational Behaviour*, 9th Edition, McGraw-Hill, 1992.
- T2. K. Aswathappa, *Organisational Behaviour*, 12th Revised Edition, Himalaya Publishing House, 2016.

Reference Books:

- R1. S. P. Robbins, *Organisational Behaviour*, 8th Edition, Prentice Hall of India, 2018.
- R2. K. B. L. Srivastava and A. K. Samantaray, *Organizational Behaviour*, 1st Edition, India Tech, 2009.
- R3. K. Singh, *Organizational Behaviour*, 3rd Edition, Pearson, 2015.

Online Resources:

1. <https://nptel.ac.in/courses/110/105/110105033/>: by Dr. S. Mukhopadhyay, IIT Kharagpur
2. <https://nptel.ac.in/courses/110/105/110105120/>: by Prof. K. B. L. Srivastava, IIT Kharagpur
3. <https://www.studocu.com/en/search/organizational-behaviour>: by different universities

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

| | |
|-----|--|
| CO1 | Describe the developments in the field of OB and the micro & macro approaches inside organizations. |
| CO2 | Analyze and compare different models used to explain individual behaviour related to motivation, learning, perception and personality. |
| CO3 | Identify the processes used in developing communication, interpersonal relations and resolving conflicts. |
| CO4 | Explain the role of group dynamics, demonstrate skills required for working in groups, team building and various leadership styles. |
| CO5 | Explain the need of organizational culture and identify the process and barriers for implementing organizational change. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO6 | 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. |
| PO7 | 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. |
| PO8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| PO9 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO10 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Fundamentals of DBMS | L-T-P | Credits | Marks |
|------|---------------|----------------------|-------|---------|-------|
| OE | BTCS-T-OE-040 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of the course is to introduce the fundamental aspects involved in the design, implementation, and operation of relational database systems, learn & use data manipulation language, explore the details of transaction processing, concurrency control, and recovery techniques. |
| Pre-Requisites | Basic knowledge of data structures, algorithms, and proficiency in any programming language is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on real-world examples. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Introduction to Database Systems: Basic concepts and definitions, three schema architecture, data independence, data models, types of data models, database languages, integrity, database users, Entity-Relationship model, Constraints & Keys, Extended Entity Relationship model, Relational model, Mapping of E-R model to relational schema, System structure of DBMS, Codd's 12 Rules. | 10 Hours |
| Module-2 | Query Languages: Relational Algebra, basic operations, join operations, grouping & aggregation, Tuple Relational Calculus, Domain Relational Calculus, Query-By-Example, Structured Query Language (SQL): Create/Alter Tables, Constraints, Selection, Insertion, Modification, Deletion, Functions, Joins, Views. | 10 Hours |
| Module-3 | Database Design: Functional dependencies, Armstrong axioms, Attribute closure, Normalization: Dependency & attribute preservation, lossless join; Normal Forms: 1NF, 2NF, 3NF, BCNF, Testing for lossless design, Multi-Valued Dependency (MVD), 4NF and 5NF. | 8 Hours |
| Module-4 | Storage Strategies: Storage Architecture, File and Record Organization, Types of Indexes, B-Tree, B+ Tree, Index Files, Hashing; Query processing and optimization: Evaluation of Relational Algebra expressions, Query Optimization. | 7 Hours |
| Module-5 | Transaction Processing: Basic concepts, ACID Properties, Serializability, Concurrency Control Schemes – Lock-based & Timestamp-based protocols, Deadlock handling, deadlock prevention, detection and recovery; Database Recovery: types of database failures, Recovery techniques: log-based recovery, checkpoints, shadow paging. | 7 Hours |
| Total | | 42 Hours |

Text Books:

- T1. A. Silberschatz, H. F. Korth, and S. Sudarshan, *Database System Concepts*, 6th Edition, McGraw-Hill, 2013.

- T2. R. Elmasri and S. B. Navathe, *Fundamentals of Database Systems*, 7th Edition, Pearson Education, 2016.
- T3. I. Bayross, *SQL, PL/SQL - The Programming Language of Oracle*, 1st Edition, BPB Publications, 2010.

Reference Books:

- R1. R. Ramakrishnan and J. Gekhre, *Database Management Systems*, 3rd Edition, McGraw-Hill, 2003.
- R2. R. P. Mahapatra and G. Verma, *Database Management Systems*, 1st Edition, Khanna Publishing, 2013.
- R3. C. J. Date, *Introduction to Database Systems*, 8th Edition, Pearson Education, 2003.

Online Resources:

1. <https://nptel.ac.in/courses/106104135/>: by Prof. A. Bhattacharya, IIT Kanpur
2. <https://nptel.ac.in/courses/106105175/>: by Prof. P. P. Das, IIT Kharagpur
3. <https://cs145-fa18.github.io/>
4. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-830-databasesystems-fall-2010/lecture-notes/>
5. <https://docs.oracle.com/database/121/SQLRF/toc.htm>: Oracle SQL Reference

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

| | |
|-----|---|
| CO1 | Explain the significance of database management system, its functional components, create E-R model and relational schema for databases of real world applications. |
| CO2 | Construct queries using Relational Algebra, Relational Calculus, and perform various database operations using structured query language (SQL). |
| CO3 | Design relational databases based on real-world requirements and normalize the designs using different normalization techniques. |
| CO4 | Get an insight to storage structures, various indexing techniques and access methods using those indexes, and devise optimal query execution strategies for efficient query processing. |
| CO5 | Resolve concurrency control issues in transaction processing, and recover a database to its current state in case of failures. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

Cont'd...

| | |
|------|--|
| PO6 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Algorithm Design & Analysis | L-T-P | Credits | Marks |
|------|---------------|-----------------------------|-------|---------|-------|
| OE | BTCS-T-OE-045 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of the course is to introduce the classic algorithms in various domains, techniques for designing efficient algorithms to solve computational problems and analyze their complexities. |
| Pre-Requisites | Knowledge of Discrete Mathematics and Data Structures is essential. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Introduction, definition, and characteristics of Algorithms, Growth of functions, Asymptotic analysis, Standard notations and common functions, Recurrences, Solution of recurrences by iterative and Master method; Algorithm design techniques, Divide and conquer strategy, Merge sort, Quick sort. | 9 Hours |
| Module-2 | Heaps, Building a heap, Heap sort algorithm, Priority Queue & their operations; Dynamic Programming, Elements of dynamic programming, Matrix chain multiplication, Longest Common Subsequence. | 8 Hours |
| Module-3 | Greedy algorithms, Elements of greedy strategy, Activity selection problem, Fractional Knapsack problem, Huffman codes; Data structure for disjoint sets, Disjoint set operations, Linked list representation, Path compression, Disjoint set forest. | 8 Hours |
| Module-4 | Graph algorithms and their characteristics, Breadth-first and Depth-first search, Minimum spanning trees, Kruskal and Prim's algorithms, Single-source shortest path algorithms (Dijkstra), All-pair shortest path algorithm (Floyd-Warshall). | 9 Hours |
| Module-5 | String matching algorithms (Naive, Rabin-Karp); NP-Completeness (Polynomial time, Polynomial time verification, NP-Completeness and reducibility), Examples of NP-Complete problems (without proof) - Circuit satisfiability, 3-CNF satisfiability, Clique, Vertex cover, Ham-cycle, Travelling Salesman Problem (without proof); Introduction to Approximation algorithms. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. T. H.Cormen, C.E.Leiserson, R. L.Rivest, and C. Stein, *Introduction to Algorithms*, 3rd Edition, PHI Learning, 2014.
- T2. E. Horowitz, S.Sahni, and S.Rajasekaran, *Fundamentals of Computer Algorithms*, 2nd Edition, University Press, 2015.

P.T.O

Reference Books:

- R1. J. Kleinberg and E. Tardos, *Algorithm Design*, 1st Edition, Pearson Education, 2013.
- R2. M. T. Goodrich and R. Tamassia, *Algorithm Design: Foundations, Analysis, and Internet Examples*, 1st Edition, John Wiley & Sons, 2001.
- R3. U. Manber, *Introduction to Algorithms: A Creative Approach*, 1st Edition, Addison-Wesley, 1989.

Online Resources:

1. <http://www.nptelvideos.in/2012/11/design-analysis-of-algorithms.html>
2. <http://openclassroom.stanford.edu/MainFolder/CoursePage.php?course=IntroToAlgorithms>
3. <https://www.geeksforgeeks.org/fundamentals-of-algorithms/>
4. https://www.tutorialspoint.com/design_and_analysis_of_algorithms/

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

| | |
|-----|---|
| CO1 | Design algorithms, analyze the running time for best, worst, and average-cases, and understand divide & conquer strategy considering quick-sort and merge-sort as examples. |
| CO2 | Compare Heap sort with other comparison based sorting algorithms and develop dynamic programming algorithms. |
| CO3 | Apply disjoint-set data structure and greedy algorithm design techniques in real life problems. |
| CO4 | Model a given engineering problem using graphs and design the corresponding algorithms to solve the problem. |
| CO5 | Compare various pattern matching algorithms, understand NP-Completeness and the need of approximation algorithms. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO12 | 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. |

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Industrial Automation & Control | L-T-P | Credits | Marks |
|------|---------------|---------------------------------|-------|---------|-------|
| OE | BTEI-T-OE-019 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to study the principles, operation, tuning, configuration, and applications of various process control elements including data acquisition & data presentation units for industrial applications. |
| Pre-Requisites | Knowledge of basic electrical engineering and control systems is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Data Acquisitions & Conversion: Introduction, Objective of DAS, Single channel DAS, Multichannel DAS, Data Loggers, Digital Transducer; Signal Processing Elements: ADC (Successive approximation, Dual-slope, Ramp, Flash type), DAC (R-R and R-2R ladder), Sensitive and resolutions of ADC and DAC; Computer and microcontroller systems, Microcontroller and computer software (general idea). | 9 Hours |
| Module-2 | Data Presentation Elements: Pointer-scale indicators, Digital display principles, Light-emitting diode (LED) displays, Liquid crystal displays (LCDs), Electroluminescence (EL) displays, Chart recorders, Paperless recorders, Laser printers. | 8 Hours |
| Module-3 | Process Control: Introduction to Process Control, Process Definition, Feedback Control; Controller Types: Discontinuous, Continuous, and Composite; PID Controller Tuning: Zeigler-Nichols Tuning Method, Process Reaction Curve; Digital PID Controllers: Position and Velocity algorithm. | 8 Hours |
| Module-4 | Final Control Elements: Pneumatic systems – Flapper nozzle system and its characteristics, I/P converter and pneumatic actuators; Electrical actuators: Solenoids, motors, the principle of stepper motors, elements of power electronic devices and driver circuits, Hydraulic actuators; Control valve: Types of control valve, Control valve sizing, Cavitations and flashing. | 8 Hours |
| Module-5 | Special Control Structures: Cascade Control, Feed forward Control, Feed forward-Feedback Control Configuration, Ratio Control, Selective Control, and Adaptive Control Configuration. | 9 Hours |
| Total | | 42 Hours |

Text Books:

- T1. J. P. Bentley, *Principles of Measurement Systems*, 3rd Edition, Pearson Education, 2005.
- T2. S. Bhanot, *Process Control: Principles and Applications*, 1st Edition, Oxford University Press, 2008.
- T3. C. D. Johnson, *Process Control Instrumentation Technology*, 8th Edition, Pearson, 2014.

Reference Books:

- R1. K. Kant, *Computer-Based Industrial Control*, 2nd Revised Edition, PHI Learning, 2011.

- R2. C. A. Smith and A. B. Corripio, *Principles and Practice of Automatic Process Control*, 3rd Edition, John Wiley & Sons, 2006.
- R3. M. Gopal, *Digital Control and State Variable Methods*, 2nd Edition, Tata McGraw-Hill, 2003.

Online Resources:

1. <https://nptel.ac.in/courses/108/105/108105088/>: by Prof. S. Mukhopadhyay, IIT Kharagpur
2. <https://nptel.ac.in/courses/108/105/108105062/>: by Prof. S. Sen and Prof. S. Mukhopadhyay, IIT Kharagpur

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

| | |
|-----|--|
| CO1 | Describe various data acquisition & signal processing elements used in the industry. |
| CO2 | Present the measured data using various presentation elements in a user-friendly manner. |
| CO3 | Describe the process, characteristics, types of controllers, and PID controller tuning. |
| CO4 | Identify the type of final control elements and explain its working principles. |
| CO5 | Examine & troubleshoot the various controller structures and their configurations. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Soft Skills & Interpersonal Skills Lab | L-T-P | Credits | Marks |
|------|---------------|--|-------|---------|-------|
| HS | BTBS-P-HS-021 | | 0-0-4 | 2 | 100 |

| | |
|------------------------|--|
| Objectives | The objectives of this laboratory course is to practice language skills to become effective communicators by addressing issues like speaking inhibitions. The lab comprises of individual and team activities based on the four skills of language (LSRW). |
| Pre-Requisites | Basic knowledge of English grammar and the ability to speak, read, and write using the English language is required. |
| Teaching Scheme | Regular laboratory classes with various tasks designed to facilitate communication through pair and/or team activities with regular assessments, presentations, discussions, role play, audio-visual supplements, writing activities, business writing practices and vocabulary enhancement. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|---------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|---|
| 1 | Process of Communication – Group activity. |
| 2 | Mock GD 1 – Effective Communication Skills. |
| 3 | Mock GD 2 – Subject clarity & group dynamics. |
| 4 | Mock GD 3 – Behaviour and Mannerisms. |
| 5 | GD: Test – Final Assessment. |
| 6 | Presentation Skills 1 (Group Activity: 4-5 students) – Language Fluency, Active Listening, Voice Modulation. |
| 7 | Presentation Skills 2 (Group Activity: 2-3 students) – Develop awareness of non-verbal attributes in presenters. |
| 8 | Presentation Skills 3 (in pairs) – Subject clarity and knowledge. |
| 9 | Presentation Skills: Test 1 – Individual activity. |
| 10 | Presentation Skills: Test 2 – Individual activity. |
| 11 | Verbal Ability 1 – Activity Sheets: Error identification and correction. |
| 12 | Verbal Ability 2 – Activity Sheets: synonyms, antonyms & homonyms, one word substitution, jumbled paragraphs & sentences. |
| 13 | Verbal Ability 3 – Activity Sheets: tenses, voice change. |
| 14 | Teamship & Leadership Skills 1 – Video. |
| 15 | Teamship & Leadership Skills 2 – Group activity. |
| 16 | Listening 1 – Correct Pronunciation & Stress. |
| 17 | Listening 2 – Video 1. |
| 18 | Listening 3 – Video 2. |
| 19 | Mock Interview 1 – CV and Cover Letter writing. |

Cont'd...

| Experiment-# | Assignment/Experiment |
|--------------|---|
| 20 | Mock Interview 2 – Handling FAQ's and language fluency. |
| 21 | Mock Interview 3 – Assessment. |
| 22 | Mock Interview 4 – Assessment. |
| 23 | Writing Skill 1 – Essay writing. |
| 24 | Writing Skills 2 – Precis writing. |
| 25 | Assertiveness Skills – Activity and assessment. |
| 26 | Mind Mapping & SWOC – Assessment. |
| 27 | Enhancing Reading Skills 1 – Summarising & Note-making. |
| 28 | Reading Skills 2 – Comprehension passage. |

Text Books:

- T1. M. A. Rizvi, *Effective Technical Communication*, 2nd Edition, Tata McGraw Hill, 2017.
 T2. T. Balasubramaniam, *English Phonetics for Indian Students*, 3rd Edition, Trinity Press, 2013.
 T3. M. Raman and S. Sharma, *Technical Communication: Principles and Practice*, 3rd Edition, Oxford University Press, 2015.

Reference Books:

- R1. S. Samantray, *Business Communication and Communicative English*, 3rd Edition, Sultan Chand, 2006.
 R2. S. John, *The Oxford Guide to Writing and Speaking*, 3rd Edition, Oxford University Press, 2013.
 R3. B. K. Mitra, *Personality Development and Soft Skills*, 2nd Edition, Oxford University Press, 2016.
 R4. B. K. Das et. al., *An Introduction to Professional English and Soft Skills*, Cambridge University Press, 2009.
 R5. B. K. Mitra, *Effective Technical Communication - A Guide for Scientists and Engineers*, 1st Edition, Oxford University Press, 2006.

Online Resources:

1. https://owl.purdue.edu/owl/purdue_owl.html
2. <https://www.usingenglish.com/>
3. <http://www.english-test.net/>
4. <https://www.ef.com/wwen/english-resources/>

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

| | |
|-----|---|
| CO1 | Develop the skills to use English language for effective communication. |
| CO2 | Utilise function of language in context of formality, appropriateness and sensitive issues. |
| CO3 | Formulate and structure sentences using grammatically correct English. |
| CO4 | Compose clear and effective business messages for specific purposes. |
| CO5 | Build up a strong personality and develop skills for efficient public speaking. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO6 | 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. |
| PO8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |

Cont'd...

| | |
|------|--|
| PO9 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO10 | 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. |
| PO11 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Microprocessors & Microcontrollers Lab | L-T-P | Credits | Marks |
|------|---------------|--|-------|---------|-------|
| PC | BTEC-P-PC-015 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of the course is to provide hands-on practice on programming of different microprocessors and microcontrollers and their interfacing with external devices. |
| Pre-Requisites | Basic analytical & logical understanding including basic knowledge and usage of Digital Electronics is required. |
| Teaching Scheme | Regular laboratory experiments to be conducted using hardware and software tools under the supervision of the teacher; the experiments shall consist of programming assignments. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|---------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|--|
| 1 | Programs for 16 bit arithmetic operations using 8086. |
| 2 | Programs for Sorting and Searching (using 8086). |
| 3 | Programs for String manipulation operations (using 8086). |
| 4 | Programs for Digital clock and Stop watch (using 8086). |
| 5 | Interfacing ADC and DAC. |
| 6 | Parallel Communication between two MP Kits using Mode 1 and Mode 2 of 8255. |
| 7 | Interfacing and Programming 8279, 8259, and 8253. |
| 8 | Serial Communication between two MP Kits using 8251. |
| 9 | Interfacing and Programming of Stepper Motor and DC Motor Speed control. |
| 10 | Programming using Arithmetic, Logical and Bit Manipulation instructions of 8051 microcontroller. |
| 11 | Programming and verifying Timer, Interrupts and UART operations in 8051 microcontroller. |
| 12 | Communication between 8051 Microcontroller kit and PC. |
| 13, 14 | A design problem using 8051 (such as, multi-parameter data acquisition system, voltmeter, power meter, frequency counter, traffic simulation, digital clock, etc.) |

Text Books:

- T1. R. S. Gaonkar, *Microprocessor Architecture, Programming, and Applications with the 8085*, 6th Edition, Penram International Publishing, 2013.
- T2. D. A. Patterson and J. H. Hennessy, *Computer Organization and Design: The Hardware/Software Interface*, 5th Edition, Morgan Kaufman Publishers, 2013.

Reference Books:

- R1. D. Hall, *Microprocessors and Interfacing*, 3rd Edition, McGraw-Hill Education, 2017.
- R2. K. J. Ayala, *The 8051 Microcontroller*, 3rd Edition, Cengage Learning, 2007.
- R3. K. Kant, *Microprocessors and Microcontrollers: Architecture, Programming and System Design 8085, 8086, 8051, 8096*, 2nd Edition, Prentice Hall India, 2013.

Online Resources:

1. <https://nptel.ac.in/courses/108105102/7>
2. <https://nptel.ac.in/courses/108107029/>
3. <https://nptel.ac.in/courses/108105102/38>
4. <http://www.electrical4u.com/circuit-analysis.htm>
5. <http://www.allaboutcircuits.com>
6. <https://www.electronics-tutorials.ws/>

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

| | |
|-----|--|
| CO1 | Express the fundamentals of evolution, operating concept, and assembly language programming & instruction sets of 8086 Microprocessor. |
| CO2 | Develop and apply assembly language programs using loop, branch, arithmetic, logical, shift, rotate, array & String operations. |
| CO3 | Formulate programs like finding largest/smallest numbers, check existence of data, etc. |
| CO4 | Experiment with assembly level programming of 8051 microcontroller & its functions for various applications. |
| CO5 | Analyze modes of operation of 8255 PPI and peripheral interfacing using A/D and D/A converter, Stepper motor controller, and keyboard with display interface using 8279 PIC. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Electromagnetic Waves Lab | L-T-P | Credits | Marks |
|------|---------------|---------------------------|-------|---------|-------|
| PC | BTEC-P-PC-006 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this laboratory course is to visualize curl, divergence, gradient of field, Maxwell's equations, EM wave propagation, etc. The students will get practical exposure on VSWR, reflection coefficient, Smith Chart, radiation patterns, and other characteristics of EM waves. |
| Pre-Requisites | Basic knowledge of Engineering Physics, Vector Calculus, Electric and Magnetic field and MATLAB is required. |
| Teaching Scheme | Regular laboratory experiments to be conducted using hardware and software tools under the supervision of the teacher; some experiments shall consist of programming assignments. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|--|
| 1 | Field vector analysis using MATLAB: (Gradient, Divergence, Curl, Laplacian). |
| 2 | Visualising Maxwell's equations using MATLAB. |
| 3 | Propagation of electric waves in conductors and dielectrics using MATLAB. |
| 4 | Determination of dispersion and group velocity in a parallel plate waveguide using MATLAB. |
| 5 | Finding VSWR, reflection coefficient, and input impedance of a transmission line using Smith Chart. |
| 6 | Determination of the frequency & wavelength in a rectangular waveguide working in TE ₁₀ mode. |
| 7 | Determination of VSWR, reflection coefficient of rectangular wave guide. |
| 8 | Rectangular waveguide design using HFSS. |
| 9 | Coupling Measurement of H-plane Tee, E-Plane Tee, and Magic Tee junctions with Transmission Line. |
| 10 | Show azimuth and elevation patterns of microstrip patch antenna using HFSS. |
| 11 | Radiation Pattern Measurement of a Horn Antenna . |
| 12 | Radiation Pattern Measurement of a Yagi-Uda Antenna. |

Text Books:

- T1. M. N. O. Sadiku and S. V. Kulkarni, *Principles of Electromagnetics*, 6th Edition, Oxford University Press, 2015.
- T2. E. C. Jordan and K. G. Balmain, *Electromagnetic Waves and Radiating Systems*, 2nd Edition, Pearson Education, 2009.
- T3. C. A. Balanis, *Antenna Theory: Analysis and Design*, 4th Edition, John Wiley & Sons, 2016.

Reference Books:

- R1. W. H. Hayt and J. Buck, *Engineering Electromagnetic*, 7th Edition, McGraw Hill Education, 2006.
- R2. N. N. Rao, *Fundamentals of Electromagnetics for Engineering*, 1st Edition, Pearson Education, 2009.

R3. S. Ramo, *Fields and Waves in Communication Electronics*, 3rd Edition, John Wiley & Sons, 2007.

Online Resources:

1. <https://nptel.ac.in/courses/108104087/>: by Prof. P. Kumar, IIT Kharagpur
2. <https://nptel.ac.in/courses/108/106/108106152/>: by Prof. U. Khankhoje, IIT Madras
3. <https://nptel.ac.in/courses/108/104/108104130/>: by Prof. P. Kumar, IIT Kanpur
4. <https://nptel.ac.in/courses/108/102/108102119/>: by Prof. S. Aditya, IIT Delhi
5. <https://nptel.ac.in/courses/108/101/108101090/>: by Prof. K. Sankaran, IIT Bombay

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

| | |
|-----|--|
| CO1 | Observe various operators such as curl, divergence, gradient and Maxwell's equations. |
| CO2 | Understand the propagation of electric waves in conductors and various dielectrics. |
| CO3 | Determine VSWR, reflection coefficient, and input impedance using Smith Chart. |
| CO4 | Find out the frequency & wavelength in a rectangular waveguide working in TE ₁₀ mode. |
| CO5 | Visualize the radiation patterns of various types of antennas. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Digital Communication Lab | L-T-P | Credits | Marks |
|------|---------------|---------------------------|-------|---------|-------|
| PC | BTEC-P-PC-013 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|--|
| Objectives | The objective is to provide practical exposure on digital communication systems, focusing on TDM, Pulse modulations, Digital modulation techniques as well as PC data transmission through satellite link, spreading and despreading concepts. |
| Pre-Requisites | Basic knowledge of electronics and communication is required. The laboratory experiments shall go hand-in-hand with the topics taught in the theory class. |
| Teaching Scheme | Regular laboratory experiments to be conducted under the supervision of the teacher. Demonstration will be given for each experiment. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|--|
| 1 | Study of Pulse Code Modulation. |
| 2 | Study of Time Division Multiplexing. |
| 3 | Study of the functioning of Delta modulator and Adaptive Delta Modulator. |
| 4 | Generation and reception of different types of signals like ASK, PSK, FSK. |
| 5 | Study of Quadrature-phase shift keying (QPSK). |
| 6 | Study of Quadrature Amplitude Modulation (QAM). |
| 7 | Transmit and receive three separate signals (audio, video, tone) simultaneously through satellite link. |
| 8 | Spreading and despreading using additive white Gaussian noise generation / Goldcode and other forms of spreading techniques. |
| 9 | Transmit PC data through satellite link using a satellite communication demonstration unit. |
| 10 | Study of Time Division Multiplexing and simulation of TDM using MATLAB. |
| 11 | Simulation of M-ary QAM and M-ary PSK using MATLAB. |
| 12 | Performance analysis of different digital modulation technique by using MATLAB. |

Text Books:

- T1. H. Taub, D. L. Schilling, and G. Saha, *Principles of Communication Systems*, 4th Edition, McGraw Hill Education, 2013.
- T2. B. P. Lathi and Z. Ding, *Modern Digital and Analog Communication Systems*, 4th Edition, Oxford University Press, 2010.

Reference Books:

- R1. L. W. Couch II, *Digital and Analog Communication Systems*, 8th Edition, Pearson Education, 2013.
- R2. B. Sklar, *Digital Communication - Fundamentals and Applications*, 2nd Edition, Pearson Education, 2009.

Online Resources:

1. <https://nptel.ac.in/courses/117101051/>

2. <https://nptel.ac.in/courses/108/102/108102096/>
3. <https://nptel.ac.in/content/storage2/courses/117105077/pdf-m-7/m7l38.pdf>

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

| | |
|-----|---|
| CO1 | Convert analog to digital signal and vice-versa. |
| CO2 | Transmit multiple signals using Time Division Multiplexing. |
| CO3 | Realize different digital modulation schemes and their effect in communications with the help of spectrum analyzer. |
| CO4 | Understand the functioning of satellite and how it is transmitting and receiving the signals. |
| CO5 | Explain spreading concepts and methods to spread and disspread the given signals. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Biology for Engineers | L-T-P | Credits | Marks |
|------|---------------|-----------------------|-------|---------|-------|
| BS | BTBS-T-BS-014 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to integrate the knowledge of traditional engineering and modern biology to solve problems encountered in living systems, allow engineers to analyze a problem from both an engineering and biological perspective, anticipate specific issues in working with living systems, and evaluate possible solutions. |
| Pre-Requisites | Basic knowledge of biology, chemistry, and physics is adequate. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|----------------|
| Module-1 | Introduction: Importance of Biology for Engineers, Chemical foundations and basic chemistry of cell – Carbon compounds and cell as a unit of life; Physical and chemical principles involved in maintenance of life processes; Cell Structure & Functions (Prokaryotic and Eukaryotic cells), structure and functions of cellular components cell wall, plasma membrane, endoplasmic reticulum. Transport across the cell membrane, Cell signaling, nerve impulse conduction. | 8 Hours |
| Module-2 | Metabolisms & Cell Division: Exothermic and endothermic versus endergonic and exergonic reactions; Concept of K_{eq} and its relation to standard free energy, Spontaneity, ATP as an energy currency, break down of glucose (Glycolysis and Krebs cycle) and synthesis of glucose (Photosynthesis), Energy yielding and energy consuming reactions, Concept of Energy charge. Morphology of Chromosome, Cell theory, Cell cycle and phases; Mitosis and meiosis. | 8 Hours |
| Module-3 | Genetics: Laws of heredity (Mendelian and Non-Mendelian), Molecular Genetics: Structures of DNA and RNA, Mutations – Cause, types and effects on species, Bioinformatics - brief idea. Origin of Life: Haldane and Oparins concepts; Evolution: Modern concept of natural selection and speciation – Lamarkism, Darwinism/Neo-Darwinism. | 8 Hours |
| Module-4 | Microbiology: Concept of single celled organisms, Ecological aspects of single celled organisms, Concept of species and strains, Identification and classification of microorganisms, Microscopy, Sterilization and media compositions, Growth kinetics. Microbial diseases, epidemiology and public health. Immunology: Human immune mechanism – Types of immunities; Antigen/Antibody reactions – Applications in human health; Immunological disorders: Autoimmune diseases. | 9 Hours |

Cont'd...

| Module-# | Topics | Hours |
|----------|---|----------|
| Module-5 | Biochemistry: Carbohydrates, Lipids, Nucleic acids, Amino acids & Proteins – Classification based on function and structure; Protein synthesis – Components and regulatory mechanisms; Enzymes – An overview. Biotechnology: Basic concepts on Totipotency and Cell manipulation; Plant & Animal tissue culture – Methods and uses in agriculture, medicine and health. Biological indicators, bio-sensors, bio-chips, nanobiomolecules, bio-fuel. | 9 Hours |
| Total | | 42 Hours |

Text Books:

- T1. Wiley Editorial, *Biology for Engineers*, John Wiley & Sons, 2018.
 T2. McGraw-Hill Editorial, *Biology for Engineers*, McGraw-Hill Education, 2013.

Reference Books:

- R1. A. T. Johnson, *Biology for Engineers*, 1st Edition, CRC Press, 2010.
 R2. S. Singh, T. Allen, *Biology for Engineers*, 1st Edition, Vayu Education of India, 2014.
 R3. C. D. Tampo and M. A. Lewis, *Diseases of the Human Body*, 6th Edition, F. A. Davis Co., 2016.
 R4. N. A. Campbell, L. A. Urry, M. L. Cain, S. A. Wasserman, P. V. Minorsky, and J. B. Reece, *Biology: A Global Approach*, 10th Edition, Pearson Education, 2014.

Online Resources:

- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3743984/>
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4239820/>
- <http://www.euro.who.int/data/assets/pdf/0013/102316/e79822.pdf>
- <https://www.tsijournals.com/articles/world-history-of-modern-biotechnology-and-its-applications.html>
- <https://www.tandfonline.com/doi/full/10.1080/21553769.2016.1162753>
- <https://www.genome.gov/genetics-glossary/Bioinformatics>

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

| | |
|-----|--|
| CO1 | Explain the structure, function & interaction of different types of cells and their components. |
| CO2 | Describe the concepts of metabolism, energy cycle and cell theory. |
| CO3 | Comprehend genetics, origin of life and organic evolution. |
| CO4 | Apply the concepts of microbiology & immunology for diagnosis and treatment of diseases. |
| CO5 | Recognize the biological processes like protein synthesis, action of enzymes and tissue culture. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

Cont'd...

| | |
|------|--|
| PO6 | 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. |
| PO7 | 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. |
| PO9 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO10 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Fundamentals of Management | L-T-P | Credits | Marks |
|------|---------------|----------------------------|-------|---------|-------|
| HS | BTBS-T-HS-022 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to provide basic knowledge on management of business, finance, marketing, and human resources, which will help the students to grow from a team player to a good manager in an enterprise. |
| Pre-Requisites | General knowledge of any organization and its operations is sufficient. |
| Teaching Scheme | Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with real-life examples. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Concepts of Management: Management as an art or science, the process of management, managerial skills, good managers are born, not made, management is concerned with ideas, things and people, inducing workers to put in their best, levels and types of management, evolution of management thought, managerial environment. | 8 Hours |
| Module-2 | Functions of Management: Planning and its features and process, types of plan, effective planning, Organizing and its process, formal and informal organization, directing and its elements, staffing and functions, controlling & its features and process, tools of controlling. | 6 Hours |
| Module-3 | Marketing Function: Modern concepts of marketing, marketing vs. selling, functional classification of marketing, functions of marketing management, marketing process; Marketing Mix: product and types of product, product life cycle, development of a new product, price, factors affecting price, pricing strategies; Distribution channel: role and functions, selection of a distribution channel, promotion and types of promotion, developing an advertising campaign, promotional strategies. | 12 Hours |
| Module-4 | Financial Function: Scope and objectives, financial functions, sources of finance, project appraisal, tools of financial decisions making, overview of working capital. | 6 Hours |
| Module-5 | HRM Function: Human Resource Management, Human Resource Development, importance of HRM, overview of job Analysis, job description, job specification, labour turnover; Manpower planning, recruitment, selection, induction, training and development, placement, wage and salary administration, performance appraisal, grievance handling, welfare aspects. | 10 Hours |
| Total | | 42 Hours |

Text Books:

- T1. S. A. Sherlekar and V. S. Sherlekar, *Modern Business Organization & Management*, 4th Edition, Himalaya Publishing House, 2018.

Reference Books:

- R1. C. R. Basu, *Business Organization & Management*, 4th Edition, TMH, 2010.
- R2. P. C. Tulsian and V. Pandey, *Business Organization & Management*, 1st Edition, Pearson, 2002.
- R3. P. Kotler, K. L. Keller, A. Koshy, and M Jha, *Marketing Management*, 14th Edition, Pearson, 2012.
- R4. I. M. Pandey, *Financial Management*, 11th Edition, Vikas Publishing, 2015.
- R5. K. Aswasthapa, *Human Resource Management: Text and Cases*, 7th Edition, TMH, 2013.

Online Resources:

1. <https://nptel.ac.in/courses/122108038/>
2. <https://iedunote.com/marketing-concept>
3. <https://www.tutorsonnet.com/functions-of-distribution-channel-homework-help.php>
4. <https://www.managementstudyhq.com/financial-function-types-importance-objectives.html>

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

| | |
|-----|--|
| CO1 | Describe the basic concepts of management and organization. |
| CO2 | Explain fundamental management functions such as planning, directing, organizing, leading and controlling. |
| CO3 | Adopt marketing policy by applying modern concept of marketing and select appropriate distribution channels. |
| CO4 | Apply knowledge of financial functions in management for decision making. |
| CO5 | Utilize the concepts of HRM functions to manage & develop human resources in an organization. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO6 | 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. |
| PO7 | 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. |
| PO9 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO11 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Digital VLSI Design | L-T-P | Credits | Marks |
|------|---------------|---------------------|-------|---------|-------|
| PC | BTEI-T-PC-022 | | 3-1-0 | 4 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to study the design, fabrication & testing of devices, circuits & systems using integrated micro fabrication technologies providing an in-depth coverage of the state of the art in VLSI technology. |
| Pre-Requisites | Fundamental knowledge of MOSFET and digital electronics is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Introduction: Historical Perspective, VLSI Design Methodologies, VLSI Design Flow, Design Hierarchy, Concept of Regularity, Modularity and Locality, VLSI Design Styles; Fabrication of MOSFETs: Introduction, Fabrication Processes Flow – Basic Concepts, The CMOS n-Well Process, Layout Design Rules, Stick Diagrams & Layout of complex CMOS Logic Gates (Euler Method). | 11 Hours |
| Module-2 | MOS Transistor: The Metal Oxide Semiconductor (MOS) Structure, The MOS System under External Bias, Structure and Operation of MOS Transistor (MOSFET), MOSFET Current-Voltage Characteristics, MOSFET Scaling and Small-Geometry Effects, MOSFET Capacitance. | 11 Hours |
| Module-3 | MOS Inverter Circuits: Introduction, Voltage Transfer Characteristics, Noise Margin Definitions, NMOS Transistors as Load Devices, CMOS Inverters, Sizing Inverters; Static MOS Gate Circuits: Introduction, CMOS Gate Circuits, Complex CMOS Gates, MUX Circuits, Calculation of Inverter Equivalent for NAND, NOR and other Complex Logic Circuits, Flip-flops and Latches. | 12 Hours |
| Module-4 | Switching Characteristics & Interconnect Effects: Introduction, Switching Time Analysis, Design with delay constraints, Calculation of Interconnect Parasitics, Calculation of Interconnect Delay (Elmore Delay), Power Dissipation in CMOS Gates, Power and Delay Tradeoffs. | 12 Hours |
| Module-5 | Transfer Gate and Dynamic Logic Design: Introduction, Basic Concepts of Pass Transistor, CMOS Transmission Gate Logic, Dynamic logic, Domino logic, NORA; Basics of Semiconductor Memory: DRAM, SRAM Cell Design & Operation, Memory Architecture; | 10 Hours |
| Total | | 56 Hours |

Text Books:

- T1. S. -M. Kang and Y. Leblebici, *CMOS Digital Integrated Circuits - Analysis and Design*, 3rd Edition, TMH, 2002.

- T2. D. A. Hodges, H. G. Jackson, and R. Saleh, *Analysis and Design of Digital Integrated Circuits in Deep Submicron Technology*, 3rd International Edition, McGraw Hill Education, 2004.

Reference Books:

- R1. J. M. Rabaey, A. P. Chandrakasan, and B. Nikolić, *Digital Integrated Circuits: A Design Perspective*, 2nd Edition, Pearson Education, 2016.
 R2. N. H. E. Weste, D. Harris, and A. Banerjee, *CMOS VLSI Design - A Circuits and Systems Perspective*, 4th Edition, Pearson Education, 2010.
 R3. R. J. Baker, *CMOS Circuit Design, Layout, and Simulation*, 3rd Edition, John Wiley & Sons, 2010.
 R4. D. A. Pucknell and K. Eshraghian, *Basic VLSI Design*, 3rd Edition, PHI Learning, 1995.

Online Resources:

1. <https://nptel.ac.in/courses/117/106/117106092/>
2. <https://nptel.ac.in/courses/117/106/117106093/>
3. <https://nptel.ac.in/courses/117101058/>
4. <https://nptel.ac.in/courses/108/107/108107129/>
5. <https://nptel.ac.in/courses/106/105/106105161/>

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

| | |
|-----|---|
| CO1 | Identify suitable method to design circuits and systems using modern tools by following appropriate design flow and fabrication steps. |
| CO2 | Understand the structure and operational analysis of MOSFET under external bias condition before and after scaling. |
| CO3 | Design, implement and investigate Inverter, combinational and sequential logic circuits using CMOS technology. |
| CO4 | Investigate switching characteristics of inverter to estimate its delay time and power consumption. |
| CO5 | Design and analyze transmission gates, various memory cells, acquire the knowledge of different testing techniques and their reliability. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

Cont'd...

| | |
|------|--|
| PO6 | 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. |
| PO7 | 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. |
| PO11 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Information Theory & Coding | L-T-P | Credits | Marks |
|------|---------------|-----------------------------|-------|---------|-------|
| PE | BTEC-T-PE-042 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of the course is to study the concepts of information theory, measuring information using traditional & modern coding techniques including linear block, cyclic, and convolutional codes for error control. |
| Pre-Requisites | Fundamental knowledge of probability theory, random variables and basics of linear algebra is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Information Theory: Information and entropy, Entropy for discrete ensembles, Properties of entropy of a binary memory less source, Measure of information, Source coding, Shannon's noiseless coding theorem, Shannon-Fano coding, Entropy rate of a stochastic process. | 8 Hours |
| Module-2 | Source Coding and Decoding Techniques: Kraft-McMillan Inequality and Compact Codes, Huffman codes and uniquely detectable codes, Arithmetic Coding, Predictive Coding, Lempel Ziv coding. | 9 Hours |
| Module-3 | Channel Capacity: Markov Source, Joint and Conditional Information Measures, Properties of Joint and Conditional Information Measures and a Markov Source, Differential entropy, Channel models, Channel capacity, Channel coding, Information capacity theorem, the Shannon Limit Theorem, Channel capacity for MIMO systems. | 9 Hours |
| Module-4 | Channel Coding: Introduction to cyclic codes, Polynomials, the Division Algorithm for polynomials, Method for generating cyclic codes, Matrix description of cyclic codes, Burst error correction, Fire codes, Golay codes. | 8 Hours |
| Module-5 | Error Control Coding: Introduction to convolutional codes, Tree codes & Trellis codes, Polynomial description of convolutional codes, the Generating Function, Matrix description of convolutional codes, Viterbi decoding of convolutional codes. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. R. Bose, *Information Theory, Coding and Cryptography*, 3rd Edition, Tata McGraw-Hill, 2016.
- T2. N. Abramson, *Information and Coding*, McGraw-Hill Education, 1963.

Reference Books:

- R1. M. Mansurpur, *Introduction to Information*, McGraw Hill, 1987.
- R2. R. B. Ash, *Information Theory*, Dover Publications, 1990.
- R3. S. Lin and D. J. Costello Jr., *Error Control Coding*, Prentice Hall, 1983.

Online Resources:

1. <https://nptel.ac.in/courses/108/103/108103112/>: by Prof. P. K. Bora, IIT Guwahati
2. <https://nptel.ac.in/courses/117/108/117108097/>: by Prof. P. S. Nuggehalli, IISc Bangalore
3. <https://nptel.ac.in/courses/117/101/117101053/>: by Prof. S. N. Merchant, IIT Bombay
4. <https://nptel.ac.in/courses/117/104/117104120/>: by Prof. A. Banerjee, IIT Kanpur
5. <https://nptel.ac.in/courses/117/104/117104121/>: by Prof. A. Banerjee, IIT Kanpur
6. <https://nptel.ac.in/courses/117/106/117106031/>: by Dr. A. Thangaraj, IIT Madras

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

| | |
|-----|--|
| CO1 | Describe the concept of information and entropy of a source. |
| CO2 | Explain the Shannon's theorem for coding and source coding techniques. |
| CO3 | Analyze conditional information measure and Markov source. |
| CO4 | Analyze different channels and calculation of channel capacity. |
| CO5 | Apply channel coding techniques for error control. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | IoT & Applications | L-T-P | Credits | Marks |
|------|---------------|--------------------|-------|---------|-------|
| PE | BTEI-T-PE-043 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to study the design, deployment, protocols, networking, and security aspects of Internet of Things. This course also covers IoT system implementation using Arduino and Raspberry Pi, data analytics, and some case studies in various application domains. |
| Pre-Requisites | Basic knowledge of computer networks, internet technology, basic electronics, analog electronics, digital electronics and computer programming is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions shall focus on design, programming, and applications of IoT. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Introduction: Introduction to IoT, Physical Design, Logical Design, Enabling Technologies, Levels & Deployments, M2M, Difference between IoT and M2M, IoT Design Methodology, Network Function Virtualization, Need for IoT Systems Management, Simple Network Management Protocol (SNMP) and its limitations, Network Operator Requirements, NETCONF, YANG; Energy harvesting techniques. | 9 Hours |
| Module-2 | Domain-Specific IoTs: Overview, Home Automation, Smart Cities, Environment, Retail, Logistics, Agriculture, Industry, Health & Lifestyle IoT in Energy Sectors, Virtual Sensors; Generic Web-Based Protocols (SOAP, REST, HTTP, RESTful, and WebSockets), IoT Application Layer Protocols (CoAP, MQTT, AMQP, REST and XMPP). | 7 Hours |
| Module-3 | Sensing Technology: Temperature Sensor (RTD, Thermistor, Thermocouple, IC type), Humidity sensor: Capacitive, Displacement sensor: LVDT, Acceleration sensor (Potentiometric, LVDT, Piezoelectric, variable reluctance type), Pressure sensor (Diaphragm type); ADC concept; S/C Applications: Deflection bridge, amplifier, integrator, and differentiator. | 9 Hours |
| Module-4 | IoT using Arduino: Interoperability in IoT, Arduino Programming, Integration of Sensors and Actuators, Microcontrollers, Embedded C programming, Analog Interfacing, Serial, SPI, I2C, Ethernet-based data Communication; DHCP, Web Client, Telnet, MQTT; IoT using Raspberry Pi: Introduction, Linux on Raspberry Pi, Implementation of IoT with Raspberry Pi, Raspberry Pi Interfaces: Serial, SPI, I2C. | 10 Hours |
| Module-5 | Data Analytics for IoT: Introduction, Apache Hadoop: MapReduce programming model, MapReduce job execution, job execution workflow, Hadoop cluster setup, YARN, Apache Oozie: setting of Oozie, Oozie workflow for IoT data analysis; Apache Spark, Apache Storm. | 7 Hours |
| Total | | 42 Hours |

Text Books:

- T1. A. Bahga and V. Madisetti, *Internet of Things: A Hands-On Approach*, 1st Edition, Orient Blackswan, 2015.
- T2. M. Schwartz, *Internet of Things with Arduino Cookbook*, Packt Publishing, 2016.
- T3. C. D. Johnson, *Process Control Instrumentation Technology*, 8th Edition, Pearson Education, 2014.

Reference Books:

- R1. A. K. Ghosh, *Introduction to Measurement and Instrumentation*, 3rd Edition, PHI, 2009.
- R2. R. Kamal, *Internet of Things: Architecture and Design Principles*, 1st Edition, McGraw-Hill, 2017.
- R3. J. P. Bentley, *Principles of Measurement Systems*, 4th Edition, Pearson Education, 2005.

Online Resources:

1. <https://nptel.ac.in/courses/106/105/106105195/>: by Prof. S. Misra, IIT Kharagpur.
2. <https://nptel.ac.in/courses/108/108/108108098/>: by Prof. T. V. Prabhakar, IISc Bangalore
3. <https://nptel.ac.in/courses/106/105/106105166/>: by Prof. S. Misra, IIT Kharagpur
4. <https://nptel.ac.in/courses/108/105/108105064/>: by Prof. A. Barua, IIT Kharagpur
5. <https://nptel.ac.in/courses/106/106/106106182/>: by Prof. S. Iyengar, IIT Madras
6. <https://nptel.ac.in/courses/115/104/115104095/>: by Prof. M. Verma, IIT Kanpur
7. <https://nptel.ac.in/courses/106/104/106104189/>: by Dr. R. Misra, IIT Patna

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

| | |
|-----|---|
| CO1 | Explain the basics of IoT technologies, design methodologies, and network management protocols. |
| CO2 | Evaluate the domain-specific IoT and communication protocols. |
| CO3 | Describe the concepts of sensors, signal conditioning circuits, and their application to IoT. |
| CO4 | Develop programs for IoT Applications using Arduino and Raspberry Pi. |
| CO5 | Understand the concepts of IoT data analytics. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Robotics & Robot Applications | L-T-P | Credits | Marks |
|------|---------------|-------------------------------|-------|---------|-------|
| PE | BTEC-T-PE-043 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to learn the fundamental concepts of robotics, such as manipulators, kinematics, trajectory planning, control techniques, sensors etc., and basic robot programming for various industrial applications. |
| Pre-Requisites | Basics of Engineering Mathematics, Digital Electronics, Microprocessors & Microcontrollers, Automation & Control etc., are required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on programming & applications. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Robot Fundamentals: History of robotics, Basic concepts, Robot Anatomy, Robot Specification and work volume, Type of robot drives, Basic robot motions, Robot Manipulators, Kinematics, Precision movement. | 9 Hours |
| Module-2 | End Effectors: Introduction, Classification, Mechanical, Magnetic, Vacuum and Adhesive gripper, Gripper force analysis & design, Problem on gripper design and force calculation, Robot control - Unit control system concept, Servo & non-servo control of robot joints, Adaptive and optimal control. | 8 Hours |
| Module-3 | Sensors: Sensor devices, Types of sensors - contact, position and displacement sensors, force and torque sensors, Proximity and range sensors, Acoustic sensors, Robot vision systems - sensing and digitizing, Image processing and analysis. | 8 Hours |
| Module-4 | Robot Programming: Robot language, Classification, Programming methods, Lead through method, Teach pendent method, VAL systems and language, Simple program, Welding robot program, Program on loading/unloading. | 9 Hours |
| Module-5 | Industrial Applications: Application of robots, Material handling, Machine loading and unloading, Assembly robot, Inspection, Mobile robot, Microbots, Recent developments in robotics, safety considerations. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. S. R. Deb and S. Deb, *Robotics Technology and Flexible Automation*, 2nd Edition, Tata McGraw-Hill, 2009.
- T2. J. J. Crag, *Introduction to Robotics: Mechanics and Control*, 3rd Edition, Pearson, 2004.
- T3. S. K. Saha, *Introduction to Robotics*, 2nd Edition, Tata McGraw-Hill, 2009.

Reference Books:

- R1. R. K. Mittal and I. J. Nagrath, *Robotics and Control*, 1st Edition, Tata McGraw-Hill, 2003.
- R2. K. S. Fu, R. C. Gonzalez, and C. S. G. Lee, *Robotics: Control, Sensing, Vision and Intelligence*, 1st Edition, McGraw-Hill, 1987.

R3. N. Odrey, M. Weiss, M. Groover, R. N. Nagel, and A. Dutta, *Industrial Robotics: Technology, Programming and Application*, 2nd Edition, McGraw-Hill, 2012.

Online Resources:

1. <https://nptel.ac.in/courses/112/107/112107289/>: by Prof. N. Sukavanam and Prof. M. F. Orlando, IIT Roorkee
2. <https://nptel.ac.in/courses/112/105/112105249/>: by Prof. D. K. Pratihar, IIT Kharagpur
3. <https://nptel.ac.in/courses/112/101/112101099/>: by Prof. P. Seshu, Prof. P. S. Gandhi, Prof. K. K. Issac, Prof. B. Seth, and Prof. C. Amarnath, IIT Bombay

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

| | |
|-----|---|
| CO1 | Describe robot fundamentals, drives, Manipulators, movements and kinematics. |
| CO2 | Explain various classes of end effectors and robot control techniques. |
| CO3 | Describe the working of sensors and vision systems and analyze the sensed data. |
| CO4 | Write programs to make the parts of a robot function as per the needs. |
| CO5 | Design & develop robots for various industrial applications in the real world. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO7 | 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. |
| PO12 | 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. |

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Digital Image & Video Processing | L-T-P | Credits | Marks |
|------|---------------|----------------------------------|-------|---------|-------|
| PE | BTEC-T-PE-044 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to study the fundamentals, transformation, filtering, restoration, compression, and segmentation of images & videos, and their applications in various real life problems. |
| Pre-Requisites | Basics of matrices, 1-D convolution & filters, DSP, DFT, DCT, etc. are required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Image Fundamentals: Fundamental steps in digital image processing, Image sensing and acquisition, Image formation model. Image sampling and quantization, Spatial and intensity resolution, Relationship between pixels, Distance measure. Basic Intensity Transformation Functions: Image negative, Log transformation, Power-law transformations, Piecewise linear transformation functions, Contrast stretching, Intensity-level slicing, Bit-plane slicing, Histogram Processing, Histogram equalization. | 8 Hours |
| Module-2 | Spatial & Frequency Domain Filters: Mechanics of spatial filtering, Spatial correlation and convolution, Smoothing spatial filters, Sharpening spatial filters, Unsharp masking and high-boost filtering, Filtering in frequency domain, Image smoothing and sharpening in frequency domain using ideal, Butterworth, Gaussian, and Homomorphic filters. | 8 Hours |
| Module-3 | Image Restoration: A model of image degradation / restoration process, Noise models, Restoration in the presence of noise, Order statistics filters, Linear position invariant degradations, Estimating the degradation function, inverse filtering. Color Image Processing: Color fundamentals, Color models, Color conversions, Pseudo-color processing, Basics of full color image processing. | 8 Hours |
| Module-4 | Image Segmentation: Point, line and edge detection, Edge linking and boundary detection, Thresholding, Global, Adaptive and region-based segmentation. Image Compression: Fundamentals, Redundancy, Entropy, Some basic compression methods, Huffman coding, Arithmetic coding, LZW coding, Block transform coding, Predictive coding, Lossy predictive coding. | 9 Hours |
| Module-5 | Video Coding: Inter-frame redundancy, Motion estimation, Motion prediction, Elements of a video encoder and decoder; Video coding standards – MPEG-4 and H.264. Video Segmentation: Temporal segmentation – Shot boundary detection, Motion-based spatial segmentation; Video object detection & tracking. | 9 Hours |
| Total | | 42 Hours |

Text Books:

- T1. R. C. Gonzalez and R. E. Woods, *Digital Image Processing*, 3rd Edition, Pearson Education, 2008.
 T2. M. Tekalp, *Digital Video Processing*, 2nd Edition, Prentice Hall of India, 2015.

Reference Books:

- R1. A. K. Jain, *Fundamentals of Digital Image Processing*, 2nd Edition, Prentice Hall of India, 2004.
 R2. S. Sridhar, *Digital Image Processing*, 2nd Edition, Oxford University Press, 2014.
 R3. A. L. Bovik, *A Handbook of Image and Video Processing*, 2nd Edition, Academic Press, 2000.
 R4. S. Jayaraman, S. Esakkirajan, and T. Veerakumar, *Digital Image Processing*, 2nd Edition, McGraw-Hill Education, 2013.

Online Resources:

1. <https://nptel.ac.in/courses/117105079/>: by Prof. P. K. Biswas, IIT Kharagpur
2. <https://nptel.ac.in/courses/117105135/>: by Prof. P. K. Biswas, IIT Kharagpur
3. <https://nptel.ac.in/courses/106105032/>: by Dr. G. Harit, IIT Kharagpur
4. <https://nptel.ac.in/courses/117/104/117104069/>: by Prof. S. Gupta, IIT Kanpur

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

| | |
|-----|---|
| CO1 | Describe fundamental concepts of image processing, its scope and applications. |
| CO2 | Explain 2D convolution in spatial & frequency domain and their implications in developing various high-pass & low-pass filters. |
| CO3 | Restore images using various schemes & adaptive filters and process color images. |
| CO4 | Segment and compress images using various techniques as per application requirement. |
| CO5 | Perform video coding and segmentation using various techniques & standards. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Analog VLSI Design | L-T-P | Credits | Marks |
|------|---------------|--------------------|-------|---------|-------|
| PE | BTEI-T-PE-013 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to study analysis & design of analog integrated circuits and systems for various applications including single-stage, differential & operational amplifiers, current mirrors & bandgap reference circuits with different specifications. |
| Pre-Requisites | Fundamentals of MOSFET, analog electronics, and network theory are required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Review of Circuits & Systems: Circuit elements and their constitutive relations; Network theory: Superposition (Linearity) and Time-Invariant principle; Design and analysis of LTI systems: KCL, KVL, Node Equation procedure, Thevenin and Norton method; Matrix formulation for CAD solution; Analysis of non-linear circuits: analytical, graphical and incremental solution; Dynamic Circuit Analysis: Solution to a first-order differential equation. | 4 Hours |
| Module-2 | Integrated Circuit Devices: Diodes – Basic operation & large-signal modeling; MOS Transistor: Large & small-signal (low & high frequency) modeling, Advanced MOS modeling (subthreshold, mobility degradation); SPICE modeling: Introduction, Diode Model, MOS Transistors, Advanced SPICE Models for MOS Transistors; Passive Devices: Resistors and capacitors; Reading process parameters from foundry documents. | 9 Hours |
| Module-3 | CMOS Processing & Layout: CMOS processing, Layout, and design rules; Reading design rules from foundry documents; Analog layout considerations - variability, mismatch, matching, noise consideration; Single-Stage Amplifiers: Common-Source, Source Follower, Common-Gate, Examples, Impedance Matching. | 10 Hours |
| Module-4 | Op-Amp: Diff-Amp, Telescopic, Folded Cascode, Two-Stage Amplifier Design; Stability: Frequency Response, Feedback, Compensation; Current Mirrors: Simple current mirror, Cascode current mirror, Wide-swing current mirror, Matching. | 10 Hours |
| Module-5 | Bandgap References: Low Power Bandgap Reference Design. Low Noise Amplifier (LNA): Design of Low Noise Amplifier. | 9 Hours |
| Total | | 42 Hours |

Text Books:

- T1. T. C. Carusone, D. A. Johns, and K. A. Martin, *Analog Integrated Circuit Design*, 2nd Edition, Wiley India, 2012.

- T2. B. Razavi, *Design of Analog CMOS Integrated Circuits*, Indian Edition, McGraw-Hill Education, 2002.
- T3. D. Holberg and P. Allen, *CMOS Analog Circuit Design*, 3rd Edition, Oxford University Press, 2013.

Reference Books:

- R1. P. Gray, P. Hurst, S. Lewis, and R. Meyer, *Analysis and Design of Analog Integrated Circuits*, 4th Edition, John Wiley & Sons, 2001.
- R2. R. J. Baker, *CMOS Circuit Design, Layout and Simulation*, IEEE Inc., 2008.
- R3. A. Agarwal and J. Lang, *Foundations of Analog and Digital Electronic Circuits*, 1st Edition, Elsevier, 2005.

Online Resources:

1. <http://cmosedu.com>
2. <http://pages.hmc.edu/harris/>
3. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/>
4. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-374-analysis-and-design-of-digital-integrated-circuits-fall-2003/>
5. <https://nptel.ac.in/courses/117/101/117101105/>
6. <https://nptel.ac.in/courses/117106030/>
7. <https://nptel.ac.in/courses/108/106/108106105/>
8. <https://nptel.ac.in/courses/108/106/108106068/>

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

| | |
|-----|--|
| CO1 | Explain the structure and operational analysis of devices like Diode, MOSFET and their large and small-signal models, design flow and fabrication steps. |
| CO2 | Describe the CMOS process and layout design for Analog Integrated Circuits. |
| CO3 | Design single-stage amplifiers for various applications. |
| CO4 | Design Op-Amps and current mirrors of different topologies for various applications. |
| CO5 | Analyze and design bandgap reference and low noise amplifiers. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

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| PO6 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Fiber Optic Communications | L-T-P | Credits | Marks |
|------|---------------|----------------------------|-------|---------|-------|
| PE | BTEC-T-PE-046 | | 3-0-0 | 3 | 100 |

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|------------------------|--|
| Objectives | The objective of this course is to study various modes, configurations and transmission characteristics of optical fibers including fiber fabrications, optoelectronic sources, photo detectors, optical modulators, optical amplifiers and various types of optical networks. |
| Pre-Requisites | Basic knowledge of physics, particularly ray optics, and electromagnetic wave propagation through waveguides is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|----------------|
| Module-1 | Introduction: Fundamentals of fiber optics, Different generations of optical fiber communication systems, Optical fiber structure, Fiber types, Step index fiber, Graded index fiber, Basic optical laws & definitions, Ray propagation, Total internal reflection, Numerical aperture, Acceptance angle, Wave propagation in planar waveguides, Wave propagation in a cylindrical waveguides, Modal concept, V-number, Power flow in step & graded index fibers. | 9 Hours |
| Module-2 | Transmission Characteristics: Attenuation (absorption, scattering and bending) and dispersion (inter and intramodal, chromatic, wave guide and polarization), Dispersion shifted and Dispersion flattened fibers; Optical Fiber Cables and Connections: Fiber fabrication, Double crucible method, Fiber optic cables, Connector and splice, Losses during coupling between source to fiber, fiber to fiber; Schemes for coupling improvement. | 9 Hours |
| Module-3 | Optical Sources & Detectors: Sources - Intrinsic and extrinsic materials - direct and indirect band gaps, LED: LED structures, Surface emitting and edge emitting LED, LED quantum efficiency, Modulation response of an LED, Injection LASER Diodes (ILDs) - Threshold conditions, LASER modes, Modulation response of ILDs, Optoelectronic Detectors - PIN AND APD, Responsivity, Band width, Detector noise equivalent circuit and SNR calculation. | 8 Hours |
| Module-4 | Opto-electronic Modulators: Basic principles, Electro-optic modulators - Electro-optic effect, Longitudinal modulator, Transverse modulator; Acousto-optic modulators - Raman-Nath modulator, Bragg modulator; Optical Amplifiers: Introduction, General applications of optical amplification, Semiconductor optical amplifier (SOA) - Characteristics, Limitations, Basic principles and Optical gain, Erbium-doped fiber amplifier (EDFA) - Characteristics, Operating principle and Optical gain. | 8 Hours |

Cont'd...

| Module-# | Topics | Hours |
|--------------|---|-----------------|
| Module-5 | WDM Components & Optical Switching: WDM concept, Couplers, Isolators, Circulators, Filters, Optical Cross-connect (OXC), Optical Add/Drop Multiplexing (OADM); Optical Networks: Elements of optical Networks - SONET/SDH, Optical interfaces, SONET/SDH Rings, SONET/SDH Networks, Optical Ethernet. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. G. Keiser, *Optical Fiber Communications*, 4th Edition, Tata McGraw-Hill, 2013.
 T2. J. M. Senior, *Optical Fiber Communication: Principles and practice*, 3rd Edition, Prentice Hall of India, 2009.

Reference Books:

- R1. G. P. Agarwal, *Fiber-Optic Communication Systems*, 4th Edition, John Wiley & Sons, 2011.
 R2. R. P. Khare, *Fiber Optics and Optoelectronics*, Oxford University Press, 2004.

Online Resources:

1. <https://nptel.ac.in/courses/108/104/108104113/>: by Dr. P. Kumar, IIT Kanpur
2. <https://nptel.ac.in/courses/117/101/117101002/>: by Prof. R. K. Shevgaonkar, IIT Bombay
3. <https://nptel.ac.in/courses/117104127/>: by Dr. P. Kumar, IIT Kanpur

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

| | |
|-----|--|
| CO1 | Describe fundamentals of fiber optics, its structure, types and wave propagation through fiber. |
| CO2 | Estimate the losses and analyze the propagation characteristics of an optical signal in different types of fibers. |
| CO3 | Describe and compare the basic principles and characteristics of different types of optical sources and detectors. |
| CO4 | Analyze the performance of different types of optical modulators and amplifiers. |
| CO5 | Summarize the applications of different WDM components, optoelectronic switching circuits and optical networks. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |

Cont'd...

| | |
|------|--|
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO7 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Microwave Engineering | L-T-P | Credits | Marks |
|------|---------------|-----------------------|-------|---------|-------|
| PE | BTEC-T-PE-024 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to study microwaves, their frequency bands, microwave tubes, amplifiers, components, microwave solid state devices, principles of radar, and scanning & tracking techniques. |
| Pre-Requisites | Basic knowledge of Circuit Theory, Electromagnetic Theory, and Solid State Physics is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Microwave Tubes: Introduction, frequency bands, applications, Conventional tubes - vacuum diode, triode, tetrode, pentode; Limitations of conventional tubes, Reflex Klystron - construction, operation, velocity modulation, power output, efficiency, electronic admittance, Magnetron - construction, operation, cyclotron angular frequency, resonant modes, Hull's cutoff magnetic flux density & cutoff voltage. | 9 Hours |
| Module-2 | Microwave Amplifiers: Klystron Amplifier - construction, operation, reentrant cavities, velocity modulation, output power, beam loading, efficiency, mutual conductance, Travelling Wave Tube (TWT) - Slow wave structures, construction, amplification process. | 8 Hours |
| Module-3 | Microwave Components: Analysis using s-parameters, Junctions (E-Plane, H-Plane, Magic Tee), Directional coupler; Bends and corners; Microwave posts, S. S. tuners, Attenuators, Phase shifter, Ferrite devices (Isolator, Circulator, Gyrator); Cavity resonator. | 8 Hours |
| Module-4 | Radar Systems: Principles & operation; Range equation; Pulse repetition frequency (PRF) & range ambiguities; Doppler Radars - Determination of velocity, Continuous Wave (CW) radar and its limitations, Frequency Modulated Continuous Wave (FMCW) radar, Moving Target Indicator (MTI) radar, Delay line cancellers, Blind speeds & staggered PRFs; Scanning & Tracking - horizontal, vertical, spiral, palmer, raster, nodding; Angle tracking systems - Lobe switching, Conical scan, Mono pulse. | 9 Hours |
| Module-5 | Microwave Solid State Devices: Limitations of conventional solid state devices at microwaves; Transistors, Diodes (Tunnel, Varactor, PIN), Transferred electron devices (Gunn diode); Avalanche transit time effect (IMPATT, TRAPATT, SBD); Microwave Amplification by Stimulated Emission of Radiation (MASER). | 8 Hours |
| Total | | 42 Hours |

Text Books:

T1. D. M. Pozar, *Microwave Engineering*, 4th Edition, Wiley Publications, 2011.

- T2. S. Liao, *Microwave Devices and Circuits*, 3rd Edition, Pearson Education, 2006.
 T3. M. I. Skolnik, *Introduction to Radar Systems*, 3rd Edition, McGraw-Hill Education, 2001.

Reference Books:

- R1. G. S. Rao, *Microwave and Radar Engineering*, 1st Edition, Pearson Education, 2014.
 R2. R. E. Collin, *Foundation of Microwave Engineering*, 2nd Edition, John Wiley & Sons, 2007.
 R3. M. Kulkarni, *Microwave Devices and Radar Engineering*, 5th Edition, Umesh Publications, 2014.

Online Resources:

1. <https://nptel.ac.in/courses/108/101/108101112/>: by Prof. G. Kumar, IIT Bombay
2. <https://nptel.ac.in/courses/108/103/108103141/>: by Prof. R. Bhattacharjee, IIT Guwahati
3. <https://nptel.ac.in/courses/117/105/117105138/>: by Prof. A. Bhattacharya, IIT Kharagpur
4. <https://nptel.ac.in/courses/117/105/117105130/>: by Prof. A. Bhattacharya, IIT Kharagpur
5. <https://nptel.ac.in/courses/117/105/117105122/>: by Prof. A. Bhattacharya, IIT Kharagpur
6. <https://nptel.ac.in/courses/117/101/117101119/>: by Prof. J. Mukherjee, IIT Bombay

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

| | |
|-----|---|
| CO1 | Describe conventional vacuum tubes, their limitations, microwaves, and their sources. |
| CO2 | Explain the principle of operation of various microwave amplifiers. |
| CO3 | Identify, describe, and explain different microwave components. |
| CO4 | Explain the basic principle of Radar, various scanning and tracking techniques. |
| CO5 | Understand the principle of microwave generation using solid state devices. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Power Station Engineering | L-T-P | Credits | Marks |
|------|---------------|---------------------------|-------|---------|-------|
| OE | BTEE-T-OE-033 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to study various aspects and working of principles of power plants based on different fuels, their cost-benefit analysis, safety, and environmental issues. |
| Pre-Requisites | Basics of mechanical engineering, thermodynamics, and basic electrical engineering are required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Introduction: Sources of Energy and Generation, Indian Energy Scenario; Prediction of Load: Connected Load, Maximum Load, Demand Factor, Average Load, Load Factor, Load Duration Curves, Diversity Factor, Choice of Type of Generation, Capacity Factor, Reserve Factor, Plant Use Factor, Base Load, Intermediate Load, Peak Load Plants; Economics of Power Generation: Costs - Construction cost, Fixed cost, Costs for energy, Depreciation of plant, Fuel cost; Economic scheduling principle, Annual operating costs, Effect of Load Factor on cost, Tariff. | 9 Hours |
| Module-2 | Hydro Electric Power Station: Selection of site, Hydrological cycle, precipitation, run-off, hydrograph, flow duration & mass curves, Estimation of water held by a dam, Storage & Pondage, Earthen & Concrete Dams; Turbines: Kaplan & Francis Turbine, Pelton wheel, Speed & Pressure Regulation, Work done & Efficiency; Arrangement & location of Hydroelectric Station: Catchment area, Reservoir, Dam, Head Gate, Spillways, Pen stock, Surge Tanks, Scroll case, Draft tubes & Tail Race, Power House, Pump storage plant. | 10 Hours |
| Module-3 | Nuclear Power Station: Fission & Fusion, Principle of Nuclear Energy, Reactor Construction, Controlled Chain Reaction, Power Reactors: Pressurized Water Reactor, Boiling Water Reactor, Pressurized Heavy Water Reactor, CANDU Reactor, Gas Cooled & Liquid Metal Cooled Reactors; Operational Control of Reactors, Breeder, Location & layout of nuclear power plant. | 8 Hours |
| Module-4 | Thermal Power Station: Selection of site; Main parts & working of a Steam Station, Overall Block Diagram indicating the air circuit, coal & ash circuit, water & steam circuit, Types of steam turbines, Ash & coal handling system, High Pressure and High capacity water tube boilers, Super heaters, De-Super heater, Re-heater, Air Pre-heater; Ultra mega power project, Fluidized bed boiler technology. | 8 Hours |

Cont'd...

| Module-# | Topics | Hours |
|----------|--|----------|
| Module-5 | Fuel handling plant, water treatment plant, Draft System: Natural, Induced, Forced & Balanced Draft, ID fan, PA fan, FD fan, Chimney, Condenser, Feed water heaters, Evaporators, Make-up water, Bleeding of steam, Cooling water system; Electrostatic precipitator, Water treatment plant, Turbine, Fluidized bed combustor, Economizer, Generators, Dust collector system, Condenser, Cooling tower, Feed water pump. | 7 Hours |
| Total | | 42 Hours |

Text Books:

- T1. P. K. Nag, *Power Plant Engineering*, 4th Edition, Tata McGraw Hill, 2014.
 T2. M. V. Deshpande, *Elements of Electrical Power Station Design*, 3rd Edition, PHI, 2010.
 T3. B. G. A. Skrotzki and W. A. Vopat, *Power Station Engineering and Economy*, 2nd Edition, Tata McGraw Hill, 1988.

Reference Books:

- R1. S. C. Arora, S. Domkundwar, and A. V. Domkundwar, *A Course in Power Plant Engineering*, 6th Edition, Dhanpat Rai & Sons, 2013.
 R2. R. K. Rajput, *A Text Book of Power Plant Engineering*, 3rd Edition, Laxmi Publishing, 2012.

Online Resources:

- <https://nptel.ac.in/courses/108/105/108105058/>: by Prof. S. Banerjee, IIT Kharagpur
- <https://nptel.ac.in/courses/112/103/112103275/>: by Prof. D. N. Basu, IIT Guwahati
- <https://nptel.ac.in/courses/112/106/112106133/>: by Prof. J. M. Mallikarjuna, Prof. U. S. P. Shet, and Prof. T. Sundararajan, IIT Madras

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

| | |
|-----|---|
| CO1 | Estimate loads, generation patterns, their behavior and cost benefit analysis of different types of power stations. |
| CO2 | Describe the operation of hydro power plant, different heads, and turbine modeling. |
| CO3 | Evaluate the performance of nuclear power station and realize associated problems. |
| CO4 | Explain the operation of the thermal power plant and related mechanical functions. |
| CO5 | Identify and describe different components of a thermal power plant. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |

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|-----|--|
| PO7 | 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. |
|-----|--|

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Stochastic Processes | L-T-P | Credits | Marks |
|------|---------------|----------------------|-------|---------|-------|
| OE | BTBS-T-OE-031 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objectives of this course is to gain mathematical maturity by equipping the students to handle computing probability in different conditions and studying the concepts of Markov chain & Queuing theory. |
| Pre-Requisites | Knowledge of Sets, Probability, and Linear Algebra is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Review of basics of Probability - Probability of an event, Conditional probability, Independent event and Bayes' formula, Random variables, Discrete and Continuous, Distribution functions, Joint distribution & independent random variables, Expectation, Variance and covariance, Variance of a sum, Conditional distribution & conditional expectation (discrete case), Conditional distribution & conditional expectation (continuous case), Computing expectation & variance by conditioning, Computing probabilities by conditioning. | 8 Hours |
| Module-2 | Stochastic Processes, Markov Chain - Introduction and definition, Chapman-Kolmogorov equations, Classification of states, Limiting probabilities, Some application problems, Mean time spent in transient state, Branching processes, Time reversible Markov chains. | 11 Hours |
| Module-3 | Markov decision process, Hidden Markov chain, Exponential distribution and its properties, Counting process & definition of Poisson process, Inter arrival & waiting time distribution, Further properties of Poisson process, Non-homogeneous Poisson process. | 8 Hours |
| Module-4 | Continuous-time Markov chain, Birth & death process, The transition probability function, Limiting probabilities, Time reversibility, Computing the transition probabilities. | 7 Hours |
| Module-5 | Terms & notations in Queuing Theory, Steady state probabilities, A single server exponential queuing system (M/M/1), M/M/1 system with finite capacity, An application problem, The system M/G/1, Multiserver queues. | 8 Hours |
| Total | | 42 Hours |

Text Books:

T1. S. M. Ross, *Introduction to Probability Models*, 10th Edition, Academic Press, 2009.

Reference Books:

R1. J. Medhi, *Stochastic Processes*, 4th Edition, New Age International, 2019.

Online Resources:

1. <https://nptel.ac.in/courses/110/101/110101141/>: by Prof. M. Hanawal, IIT Bombay
2. <https://nptel.ac.in/courses/111/102/111102111/>: by Dr. S. Dharmaraja, IIT Delhi
3. <https://nptel.ac.in/courses/115/106/115106089/>: by Prof. V. Balakrishnan, IIT Madras
4. <https://nptel.ac.in/courses/111/102/111102098/>: by Dr. S. Dharmaraja, IIT Delhi

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

| | |
|-----|---|
| CO1 | Apply probability models to real life engineering problems. |
| CO2 | Explain Markov chain and classification of states. |
| CO3 | Solve problems using the concepts of hidden Markov chain and Poisson process. |
| CO4 | Apply Markov chain in problems of different field of engineering. |
| CO5 | Apply Queuing theory in engineering and daily life situations. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Entrepreneurship Development | L-T-P | Credits | Marks |
|------|---------------|------------------------------|-------|---------|-------|
| OE | BTBS-T-OE-034 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to learn various aspects of becoming an entrepreneur by starting own business and making it successful so as to adopt entrepreneurship as a career option for graduating engineers. |
| Pre-Requisites | General knowledge of any business and its operations is sufficient. |
| Teaching Scheme | Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with real-life examples & case studies. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Concept of Entrepreneurship, Characteristics of successful entrepreneur, Growth of entrepreneurship in India. Role of Entrepreneurship in Economic Development, The Entrepreneurial Process, Entrepreneurial Motivation. Entrepreneurial Competencies. Developing Entrepreneurial Competencies. | 8 Hours |
| Module-2 | Ideas to Reality, creativity, innovation and Entrepreneurship, Identifying and recognizing Opportunities, Techniques for generating Ideas, Encouraging and Protecting the new ideas and selecting the right project, Ensuring your market, Market survey and Research. | 8 Hours |
| Module-3 | Business Plan - Meaning, Contents and significance, Formulation, Presentation to the investors, Techno-economic Feasibility Assessment - A preliminary Project Report, Details Project Report, Project Appraisal, Methods of Project Appraisal. | 9 Hours |
| Module-4 | Creating a successful financial plan, Basic financial statements, Ratio Analysis, Break-even Analysis; Marketing Management of SMEs, Problems of HRM – Relevant Labour – laws, Forms of Business ownership, Institutional Finance to entrepreneurs, Source of financing, Institutional support to entrepreneurs. | 9 Hours |
| Module-5 | The importance of Intellectual Property, Patents, Trade Mark, Copyrights, Trade secrets, Intellectual property audit, Start up Policy of Centre, State, and MSME sectors, Problems of MSME, Sickness in small scale enterprises, Govt. policies on revival of sickness and remedial measures. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. B. R. Barringer and R. D. Ireland, *Entrepreneurship*, 2nd Edition, Pearson Education, 2008.
 T2. Z. Thomas and S. Norman, *Essentials of Entrepreneurship and Small Business Management*, 5th Edition, PHI Learning, 2009.
 T3. S. S. Khanka, *Entrepreneurial Development*, 4th Edition, S. Chand & Co., 2010.

Reference Books:

- R1. P. Chavantimath, *Entrepreneurship Development and Small Business Enterprises*, 3rd Edition, Pearson Education, 2018.
- R2. H. D. Robert and P. M. Shephard, *Entrepreneurship*, 6th Edition, McGraw-Hill Education, 2007.
- R3. P. C. Jain, *Hand Book for New Entrepreneurs*, 4th Edition, Oxford University Press, 2004.
- R4. J. A. Timmons and S. Spinelli Jr., *New Venture Creation: Entrepreneurship for the 21st Century*, 8th Rev. Edition, Tata McGraw-Hill, 2009.
- R5. R. Roy, *Entrepreneurship Management*, 1st Edition, Oxford University Press, 2008.

Online Resources:

1. <https://nptel.ac.in/courses/110/106/110106141/>: by Prof. C. B. Rao, IIT Madras
2. <https://nptel.ac.in/courses/127/105/127105007/>: by Prof. M. K. Mondal, IIT Kharagpur
3. <https://nptel.ac.in/courses/110/107/110107094/>: by Prof. V. Sharma & Prof. R. Agrawal, IIT Roorkee

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

| | |
|-----|---|
| CO1 | Describe the importance of entrepreneurship as a tool for development and discern distinct entrepreneurial traits. |
| CO2 | Analyse the business environment to identify business opportunities and understand the systematic process to select and screen a business idea. |
| CO3 | Prepare a proper business plan and project report. |
| CO4 | Apply the tools necessary to create sustainable and viable businesses. |
| CO5 | File and obtain patents for their innovative ideas to protect the rights of their business. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO6 | 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. |
| PO7 | 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. |
| PO9 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO11 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Internet Technology & Applications | L-T-P | Credits | Marks |
|------|---------------|------------------------------------|-------|---------|-------|
| OE | BTCS-T-OE-041 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of the course is to study the technologies behind the Internet including protocols, client-side & server-side programming, and other advanced tools used to develop & deploy professional web applications. |
| Pre-Requisites | Knowledge of java, networking, and idea on Internet is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on programming activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Introduction to Internet and WWW, Client-Server model, Browsers, IP Addresses, URLs and MIME; Internet Protocols, HTTP Request/Response model; Structure of a Web page, HTML and W3C, Elements, Attributes and Tags; Basic HTML Tags, Text and Lists, Links and Tables, Images and Colors, Forms, Interactive and Multimedia Tags in HTML. Document Type Definition. | 10 Hours |
| Module-2 | Cascading Style Sheets: Introduction, Advantages, Adding CSS, Browser compatibility, Page layout, Selectors. CSS Background, CSS Border, CSS Box Model, CSS Display and Float, CSS Tables, CSS Pseudo class and elements; CSS3: Additional features (Box, Shadow and Effects). | 9 Hours |
| Module-3 | JavaScript: Introduction, Variables, Literals, Operators, Conditional Statements, Arrays, Functions, Objects (Built-in and User-defined); JavaScript and HTML DOM: Window, Location, Navigator objects, Events and Event Handlers, Navigating the DOM tree, Creating, Adding, Inserting, Removing and Replacing nodes, Document Object properties; Accessing and Validating the Form fields. | 9 Hours |
| Module-4 | XML: Use, Declaration, Elements, Attributes, Validation, Display; XML DTD: XML Schema, Validation, Using DTD in an XML Document; XML DOM and XML Transformation; AJAX: Use and benefits, Asynchronous communication, Processing steps, Sending and Retrieving information; JSP: Introduction and life cycle, JSP Service Methods, Elements in a JSP Page, JSP Objects, JSP Tags, JSP Exceptions, JSP Example. | 9 Hours |
| Module-5 | Web Services: Evolution, Purpose and Standards, Programming Models, WSDL, SOAP based web services, REST based web services; E-Commerce and Security, Digital Signature and Authentication. | 5 Hours |
| Total | | 42 Hours |

Text Books:

- T1. M. Srinivasan, *Web Technology: Theory and Practice*, 2nd Edition, Pearson Education, 2012.
 T2. U. K. Roy, *Web Technologies*, 1st Edition, Oxford University Press, 2016.

Reference Books:

- R1. T. A. Powell, *HTML & CSS: The Complete Reference*, 5th Edition, McGraw-Hill Education, 2017.
- R2. B. A. Forouzan, *Data Communication and Networks*, 4th Edition, McGraw-Hill Education, 2017.
- R3. T. A. Powell and F. Schneider, *JavaScript 2.0 - The Complete Reference*, 4th Edition, McGraw-Hill Education, 2017.

Online Resources:

1. <https://nptel.ac.in/courses/106/105/106105084/>: by Prof. I. Sengupta, IIT Kharagpur
2. <https://www.w3schools.com/html/default.asp>
3. <https://www.w3schools.com/css/default.asp>
4. <https://www.tutorialspoint.com/javascript/index.htm>

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

| | |
|-----|---|
| CO1 | Describe the basics of Internet Technology and the structure of the world wide web. |
| CO2 | Design professional web pages using HTML and CSS. |
| CO3 | Create interactive web pages using Java script and XML. |
| CO4 | Use server side programming to create dynamic web applications. |
| CO5 | Explore & make use of web services and investigate security issues in Internet. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Advanced Java Programming | L-T-P | Credits | Marks |
|------|---------------|---------------------------|-------|---------|-------|
| OE | BTCS-T-OE-042 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of the course is to learn advanced features of the Java programming language, various frameworks in J2EE for rapid development, and apply these to develop enterprise applications. |
| Pre-Requisites | Knowledge of object oriented programming using Java is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on programming activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Introduction to J2EE Environment: Overview of J2EE and J2SE. J2EE Architecture JDBC: The Concept of JDBC, JDBC Driver Types, JDBC Packages, Database Connection, CRUD Operations using JDBC, Transaction Processing, Metadata; Web Applications and Programming: Web application architecture, Client, Server (Apache Tomcat/WebLogic), HTML5, CSS3; Client Side Programming: JavaScript, JQuery; Introduction to XML/JSON. | 9 Hours |
| Module-2 | Servlets: Introduction, Servlet Architecture, Environment Setup, Life Cycle, Form Data processing, Client HTTP Request, Server HTTP Response, HTTP Status Codes, Exception Handling; Advanced Features of Servlets: Handling Cookies, Session Tracking, URL rewriting, Database access, File uploading, Date handling, Page redirection, Sending email, Packaging, Debugging, Internationalization. | 8 Hours |
| Module-3 | Java Server Pages (JSP): Advantages of JSP over Servlet, Lifecycle of a JSP page, JSP API, Scriptlet tag, Implicit objects, Directives, Exception handling, Action tags, Expression Language (EL); Advanced Features of JSP: Session Tracking, MVC, JSTL, Custom Tags, CRUD operations; JSP Sample Code: Pagination, Registration Form, File Uploading. | 8 Hours |
| Module-4 | Enterprise JavaBeans (EJB): Introduction, Session Bean, JMS (Java Message Service), Message Driven Bean (MDB), Entity Bean; Struts Framework: Introduction, Features, Model 1 and Model 2 (MVC) Architecture, Interceptors, Struts 2 Architecture & Flow, Action, Configuration File, Validation, Ajax Validation, JSON Validation, Interceptor, Zero Configuration. | 8 Hours |
| Module-5 | Java Mail API: JavaMail Architecture, Sending emails, Sending email through Gmail Server, Receiving emails, Emails with HTML content, Forwarding, Deleting; Hibernate Framework: Introduction, Architecture, Web Application with Hibernate (using XML), Generator classes; Spring Framework: Introduction, Modules, Examples, Dependency Injection, AOP, JDBC Template. | 9 Hours |
| Total | | 42 Hours |

Text Books:

- T1. J. Keogh, *J2EE: The Complete Reference*, 11th Edition, McGraw Hill, 2017.
- T2. Kogent Learning Solutions, *Java Server Programming: Java EE 7 (J2EE 1.7) Black Book*, 1st Edition, DreamTech, 2014.

Reference Books:

- R1. DT Editorial Services, *J2EE 1.7 Projects Black Book*, 1st Edition, DreamTech, 2015.
- R2. Kogent Learning Solutions, *Web Technologies: HTML, Javascript, PHP, Java, JSP, XML and Ajax, Black Book*, 2nd Edition, DreamTech, 2009.

Online Resources:

1. <https://www.tutorialspoint.com/ejb/index.htm>
2. <https://www.javatpoint.com/hibernate-tutorial>
3. <https://www.javatpoint.com/spring-tutorial>
4. <https://www.javatpoint.com/struts-2-tutorial>

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

| | |
|-----|---|
| CO1 | Explain concepts of J2EE and fundamentals of web application development. |
| CO2 | Design web applications using JSP and Servlet technologies. |
| CO3 | Design and develop complex enterprise applications using EJB frameworks. |
| CO4 | Integrate email support in web applications using J2EE mail API. |
| CO5 | Create enterprise J2EE application using Hibernate and Spring frameworks. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Virtual Instrumentation | L-T-P | Credits | Marks |
|------|---------------|-------------------------|-------|---------|-------|
| OE | BTEI-T-OE-021 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to study fundamentals, programming techniques, data acquisition systems, communication buses, and various other aspects to design & develop virtual instrumentation systems for different applications. |
| Pre-Requisites | Knowledge of sensors, transducers, actuators, analog & digital electronics, and computer programming is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on design & programming activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Introduction: Historical perspectives, advantages, block diagram & architecture of a virtual instrument, Conventional instruments vs. Traditional instruments, Data-flow techniques, Graphical programming in data-flow, Comparison with conventional programming, Distributed system using LabVIEW. | 7 Hours |
| Module-2 | VI Programming: Structures in LabVIEW, Loop behavior & inter-loop communication, Local & Global variables, Shift registers, Feedback, Auto-indexing, Loop timing, Timed loop; Other Structures: Sequence structures, Case structures, Formula node, Event structure; Arrays & Clusters, Graphs & Charts, File Input/Output, String Handling: String functions, LabVIEW string formats, Parsing of strings. | 10 Hours |
| Module-3 | Data Acquisition: Introduction, Classification of Signals, Analog interfacing: Sampling Theorem, Over-sampling, and Inter-channel Delay, ADCs, DACs Connecting signals to the DAQ: DI, RSE, NRSE, Practical vs. Ideal interfacing, Bridge Signal Sources; PC Buses: Local busses - PCI, RS232, RS422, RS485; Interface Buses: USB, PCMCIA, VXI, SCXI, PXI. | 10 Hours |
| Module-4 | Machine Vision: Basics of IMAQ vision: Digital Images, Display; Image analysis, Image processing techniques, Particle Analysis: Thresholding, Binary Morphology, Particle Measurement; Machine Vision: Edge Detection, Pattern Matching, Geometric Matching, Dimensional Measurement, Color Inspection, OCR; Machine Vision Hardware and Software. | 7 Hours |
| Module-5 | Motion Control: Motors: Servomotors, Brushless Servomotors, Stepper Motors, Linear Stepper Motors; Calculation of trajectory, Selecting the right motion controller; Move Types: Single-Axis, Point-to-Point Motion, Coordinated Multi-Axis Motion, Electronic Gearing; Motor Amplifiers and Drivers: Simple Servo Amplifiers, Stepper Motor Amplifiers, AC Servo Amplifiers, DC Servo Amplifiers. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. G. Johnson, *LabVIEW Graphical Programming*, 4th Edition, McGraw Hill, 2006.
 T2. S. Gupta and J. John, *Virtual Instrumentation using LabVIEW*, 2nd Edition, McGraw-Hill, 2010.
 T3. J. Jerome, *Virtual Instrumentation using LabVIEW*, 1st Edition, PHI Learning, 2010.

Reference Books:

- R1. K. James, *PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control*, 1st Edition, Newnes, 2000.
 R2. G. W. Johnson and R. Jeninngs, *LabVIEW Graphical Programming*, 4th Edition, McGraw-Hill Education, 2019.
 R3. P. A. Blume, *The LabVIEW Style Book*, 1st Edition, Prentice Hall, 2017.

Online Resources:

1. <http://www.nitttrchd.ac.in/sitenew1/nctel/electrical.php>
2. <http://iota.ee.tuiasi.ro/~master/Signals%20&%20DAQ.pdf>
3. http://www.setsunan.ac.jp/~shikama/LabVIEW_Elvis_Multisim/060803_Introduction_to_LabVIEW_8_in_6_Hours.pdf
4. <http://www.ece.mtu.edu/labs/EElabs/EE3010/Lecture%20Notes/Chapter%2009.pdf>
5. http://ece-research.unm.edu/jimp/415/labview/LV_Intro_Six_Hours.pdf

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

| | |
|-----|---|
| CO1 | Describe the fundamentals of Virtual Instrumentation developments and design. |
| CO2 | Apply programming skills for Virtual Instrumentation system design. |
| CO3 | Correlate data acquisition & communication for the design of indigenous Virtual Instruments. |
| CO4 | Understand the use of machine vision techniques in Virtual Instrumentation. |
| CO5 | Know the operation and drive of various motors as well as gears using Virtual Instrumentation for specific industrial applications. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |

Cont'd...

| | |
|------|--|
| PO9 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | High Frequency Engineering Lab | L-T-P | Credits | Marks |
|------|---------------|--------------------------------|-------|---------|-------|
| PC | BTEC-P-PC-021 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this laboratory course is to study the principle of operation of different microwave devices and components and conduct various experiments using these devices to visualize the radiation patterns of different types of antennas. |
| Pre-Requisites | Knowledge of electromagnetic waves and field theory is required. |
| Teaching Scheme | Regular laboratory experiments to be conducted using various microwave devices and components under the supervision of the teacher; demonstration will be given for each experiment. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|---------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|---|
| 1 | Study of microwave components and instruments. |
| 2 | Study of Reflex Klystron characteristics. |
| 3 | Determine the frequency & wavelength in a rectangular waveguide working in TE ₁₀ mode. |
| 4 | Determination of Voltage Standing Wave Ratio and Reflection coefficient of waveguide. |
| 5 | Rectangular waveguide design using HFSS. |
| 6 | Measurement of scattering parameters of Circulator / Isolators. |
| 7 | Measurement of directivity and coupling coefficient of a directional coupler. |
| 8 | Measurement of phase shift through Transmission Line set up. |
| 9 | Coupling measurement of H-plane, E-Plane and Magic Tee junctions with wave guide. |
| 10 | To measure attenuation and insertion loss of a fixed/variable attenuator. |
| 11 | To study the characteristics of the Gunn diode. |
| 12 | Measurement of Dielectric Constant of unknown material through Transmission Line set up. |
| 13 | Determination of the radiation characteristics and gain of an Horn antenna. |
| 14 | Radiation Pattern Measurement of a Yagi-Uda Antenna. |
| 15 | To show azimuth and elevation patterns of microstrip patch antenna using HFSS. |

Text Books:

- T1. D. M. Pozar, *Microwave Engineering*, 4th Edition, Wiley Publications, 2011.
- T2. S. Liao, *Microwave Devices and Circuits*, 3rd Edition, Pearson Education, 2006.
- T3. C. A. Balanis, *Antenna Theory : Analysis and Design*, 4th Edition, John Wiley & Sons, 2016.

Reference Books:

- R1. G. S. Rao, *Microwave and Radar Engineering*, 1st Edition, Pearson India Publisher, 2014.

- R2. R. E. Collin, *Foundation of Microwave Engineering*, 2nd Edition, Wiley Publications, 2007.
 R3. A. R. Harish and M. Sachidanada, *Antennas and Wave Propagation*, 1st Edition, Oxford University Press, 2007.

Online Resources:

1. <https://nptel.ac.in/courses/108/101/108101112/>: by Prof. G. Kumar, IIT Bombay
2. <https://nptel.ac.in/courses/108/103/108103141/>: by Prof. R. Bhattacharjee, IIT Guwahati
3. <https://nptel.ac.in/courses/117/105/117105138/>: by Prof. A. Bhattacharya, IIT Kharagpur
4. <https://nptel.ac.in/courses/117/105/117105130/>: by Prof. A. Bhattacharya, IIT Kharagpur
5. <https://nptel.ac.in/courses/117/105/117105122/>: by Prof. A. Bhattacharya, IIT Kharagpur
6. <https://nptel.ac.in/courses/117/101/117101119/>: by Prof. J. Mukherjee, IIT Bombay

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

| | |
|-----|---|
| CO1 | Familiarize with various microwave devices and components. |
| CO2 | Determine the frequency of the microwave signal, VSWR, and reflection coefficient of rectangular waveguide. |
| CO3 | Understand the principle of operation of different microwave components. |
| CO4 | Characterize Gunn diode and determine dielectric constant of unknown material. |
| CO5 | Visualize the radiation patterns of some test antennas. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Digital VLSI Design Lab | L-T-P | Credits | Marks |
|------|---------------|-------------------------|-------|---------|-------|
| PC | BTEI-P-PC-022 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this laboratory course is to provide hands-on exposure on preparing schematic, layout & simulation of complex digital systems using HDL (Verilog/VHDL) and their implementation on FPGA. |
| Pre-Requisites | Fundamentals of MOSFET and digital electronics is required. The laboratory experiments shall go along with the topics taught in the theory class. |
| Teaching Scheme | Regular Laboratory classes with use of ICT as and when required. Practicals are planned to be interactive with focus on problem solving activities and real time applications with the help of software, FPGA and other peripherals. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|---------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|---|---|
| Group A: Schematic, Layout and its Simulation (any five) | |
| 1 | Design a schematic and simple layout for CMOS Inverter, parasitic extraction and simulation. |
| 2 | Design a schematic and simple layout for CMOS NAND gate, parasitic extraction and simulation. |
| 3 | Design a schematic and simple layout for CMOS NOR gate, parasitic extraction, and simulation. |
| 4 | Design a schematic and simple layout for simple and complex Boolean expressions. |
| 5 | Design and simulation of Full adder. |
| 6 | Design and simulation of MUX, De-MUX. |
| 7 | Design and simulation of the D flip-flop. |
| 8 | Design and simulation of dynamic logic implementation (Domino logic). |
| 9 | Design and simulation of dynamic logic implementation (NORA logic). |
| 10 | Design and simulation of an ALU or a 4-bit Microprocessor with limited instructions. |
| Group B: HDL (Verilog/VHDL) for Digital Circuits and its Implementation on FPGA (any five) | |
| 11 | Design, Test Bench Creation, and Simulation of Full Adder and its FPGA Implementation. |
| 12 | Design, Test Bench Creation, and Simulation of Full Subtractor and its FPGA Implementation. |
| 13 | Design, Test Bench Creation, and Simulation of 4:1 MUX & 1:4 De-MUX and its FPGA Implementation. |
| 14 | Design, Test Bench Creation, and Simulation of 4-bit up/down Counter and its FPGA Implementation. |
| 15 | Design, Test Bench Creation, and Simulation of 4-bit Shift Register and its FPGA Implementation. |

Cont'd...

| Experiment-# | Assignment/Experiment |
|--------------|---|
| 16 | Design of ADC & DAC and their FPGA Implementation. |
| 17 | Design of Traffic Light Controller and its FPGA Implementation. |
| 18 | Design of DC Motor and its FPGA Implementation. |
| 19 | Design of Stepper Motor and its FPGA Implementation. |
| 20 | Design of Real-Time Clock and its FPGA Implementation. |

Text Books:

- T1. S. -M. Kang and Y. Leblebici, *CMOS Digital Integrated Circuits - Analysis and Design*, 3rd Edition, TMH, 2002.
- T2. D. A. Hodges, H. G. Jackson, and R. Saleh, *Analysis and Design of Digital Integrated Circuits in Deep Submicron Technology*, 3rd International Edition, McGraw Hill Education, 2004.

Reference Books:

- R1. J. M. Rabaey, A. P. Chandrakasan, and B. Nikolić, *Digital Integrated Circuits: A Design Perspective*, 2nd Edition, Pearson Education, 2016.
- R2. N. H. E. Weste, D. Harris, and A. Banerjee, *CMOS VLSI Design - A Circuits and Systems Perspective*, 4th Edition, Pearson Education, 2010.
- R3. R. J. Baker, *CMOS Circuit Design, Layout, and Simulation*, 3rd Edition, John Wiley & Sons, 2010.
- R4. D. A. Pucknell and K. Eshraghian, *Basic VLSI Design*, 3rd Edition, PHI Learning, 1995.

Online Resources:

1. <http://vlsi-iitg.vlabs.ac.in/>
2. <https://www.edaplayground.com/>
3. <http://cmosedu.com/>

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

| | |
|-----|--|
| CO1 | Explain the VLSI Design flow from start to finish. |
| CO2 | Design and implement digital systems using different architectures of VHDL. |
| CO3 | Design, implement, and investigate Inverter, combinational, and sequential logic circuits using CMOS technology. |
| CO4 | Implement digital logic circuits in real time using FPGA. |
| CO5 | Understand the timing diagram of combinational and sequential logic circuits. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |

Cont'd...

| | |
|------|--|
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO7 | 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. |
| PO11 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Skill Lab & Project-I | L-T-P | Credits | Marks |
|------|---------------|-----------------------|-------|---------|-------|
| PJ | BTEC-P-PJ-022 | | 0-0-4 | 2 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of the laboratory course is to additional skills as well as apply the knowledge gained by executing a project in electronics and communication using various hardware/software tools. |
| Pre-Requisites | Knowledge of basic electronics engineering, analog & digital electronics, microprocessors & microcontrollers, antenna fundamentals, knowledge of analog & digital communication etc., are required. |
| Teaching Scheme | Regular laboratory classes with the use of different software and hardware tools as per the requirement. Projects shall be executed by guidance & regular interaction with the assigned faculty mentor. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|------------------------|---|
| <i>Software Skills</i> | |
| 1 | Introduction to Programming & Simulation software like C, C++, Python etc. |
| 2 | Functionality of LED, Photo Diode, Photo Transistor, Sensors, Relays etc. Studying different types of Sources. |
| 3 | Using Transistor, MOSFET in various applications, uses of 555 timers. |
| 4 | Design of flip-flops and counters of given specifications as per requirements. |
| 5 | Study of microprocessors and design of microcontrollers depending on the requirements. |
| 6 | Design of Transmitting and Receiving circuit, its analysis, bandwidth, range, noise calculations etc. |
| <i>Hardware Skills</i> | |
| 1 | Design of Power Supply Unit with Rectifiers, Filters and Regulators. (Transformer Design: Shell type, 12-0-12 V, 5A center tapped transformer.) |
| 2 | Various applications of image processing like automatic attendance, face recognition etc. |
| 3 | Design of Smart Helmet (without which vehicle won't run). |
| 4 | Home Automation System. |
| 5 | Microcontroller based application design like floor mopping, wheel chair etc. |
| 6 | Sensor Based application oriented design like attendance system, Obstacle avoidance, Smart irrigation system etc |
| 7 | Applications of Robotics like firefighting, threat detection etc. |
| <i>Project Work</i> | |
| 1 | Software-based Project, presentation & viva-voce |
| 2 | Hardware-based Project, presentation & viva-voce |

Text Books:

- T1. S. Attaway, *MATLAB : A Practical Introduction to Programming and Problem Solving*, 3rd Edition, Butterworth-Heinemann, 2013.
- T2. M. Mano and M. D. Ciletti, *Digital Design with an Introduction to Verilog HDL*, 5th Edition, Pearson Education, 2013.
- T3. R. L. Boylestad and L. Nashelsky, *Electronic Devices and Circuit Theory*, 11th Edition, Pearson Education, 2015.
- T4. A. S. Sedra and K. C. Smith, *Microelectronic Circuits*, 7th Edition, Oxford University Press, 2014.
- T5. R. S. Gaonkar, *Microprocessor Architecture, Programming and Applications with the 8085*, 6th Edition, Penram International Publishing, 2013.
- T6. H. Taub, D. L. Schilling, and G. Saha, *Principles of Communication Systems*, 4th Edition, Tata McGraw-Hill, 2013.

Reference Books:

- R1. J. G. Proakis and D. G. Manolakis, *Digital Signal Processing: Principles, Algorithms and Applications*, 4th Edition, Prentice Hall India, 2007.
- R2. B. P. Lathi, Z. Ding, and H. M. Gupta, *Modern Digital and Analog Communication Systems*, 4th Edition, Oxford University Press, 2017.

Online Resources:

1. <https://nptel.ac.in/courses/117106088/>
2. <https://nptel.ac.in/courses/108107029/>
3. <https://nptel.ac.in/courses/108105102/>
4. <https://nptel.ac.in/courses/108/101/108101092/>
5. <https://nptel.ac.in/content/storage2/courses/112103174/pdf/mod2.pdf>

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

| | |
|-----|---|
| CO1 | Solve a given real life problem relevant to electronics & communication. |
| CO2 | Find an appropriate solution through practical hardware setup or software simulation. |
| CO3 | Present the results of project work comprehensively through proper presentation. |
| CO4 | Prepare comprehensive report of the project with literature survey and future scope. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

Cont'd...

| | |
|------|--|
| PO6 | 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. |
| PO7 | 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. |
| PO8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| PO9 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO10 | 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. |
| PO11 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

Part IV

4th Year B. Tech. (ECE)

Curriculum Structure (Regular)

| Semester VII | | | | | | | | |
|--------------|----------------------------------|---|--------------|---|---|------------------|---|---|
| Type | Code | Course Title | WCH L-T-P | | | Credits L-T-P | | |
| THEORY | | | | | | | | |
| PE | | Professional Elective - IV | 3 | 0 | 0 | 3 | 0 | 0 |
| OE | | Open Elective - IV | 3 | 0 | 0 | 3 | 0 | 0 |
| OO | | MOOC - I | 0 | 0 | 0 | 3 | 0 | 0 |
| PRACTICAL | | | | | | | | |
| PE | BTEC-P-PE-023 / BTBS-P-PE-024 | Emerging Technologies Lab / Entrepreneurship Project | 0 | 0 | 4 | 0 | 0 | 2 |
| PJ | BTII-P-PJ-003 | Summer Internship - III | 0 | 0 | 0 | 0 | 0 | 1 |
| | | SUB-TOTAL | 6 | 0 | 4 | 9 | 0 | 3 |
| | | TOTAL | 10 | | | 12 | | |

| Semester VIII | | | | | | | | |
|---------------|---------------|---|--------------|---|----|------------------|---|----|
| Type | Code | Course Title | WCH L-T-P | | | Credits L-T-P | | |
| THEORY | | | | | | | | |
| PE | | Professional Elective - V | 3 | 0 | 0 | 3 | 0 | 0 |
| PE | | Professional Elective - VI | 3 | 0 | 0 | 3 | 0 | 0 |
| OO | | MOOC - II | 0 | 0 | 0 | 3 | 0 | 0 |
| PRACTICAL | | | | | | | | |
| PJ | BTEC-P-PJ-029 | Presentation Skills & Technical Seminar | 0 | 0 | 4 | 0 | 0 | 2 |
| PJ | BTEC-P-PJ-032 | Project - II | 0 | 0 | 16 | 0 | 0 | 8 |
| VV | BTEC-P-VV-028 | Comprehensive Viva | 0 | 0 | 0 | 0 | 0 | 1 |
| | | SUB-TOTAL | 6 | 0 | 20 | 9 | 0 | 11 |
| | | TOTAL | 26 | | | 20 | | |

| | | | | | | | | |
|--|--|----------------------------------|------------|--|--|------------|--|--|
| | | GRAND TOTAL (8 SEMESTERS) | 201 | | | 162 | | |
|--|--|----------------------------------|------------|--|--|------------|--|--|

Note:

1. Approved list of courses for MOOC-I & II (self study) shall be published by the department.
2. Courses offered under each elective are given in "List of Electives" on Page 222.

Curriculum Structure (PS-7)
(For Students opting for Practice School / Industry Internship in the 7th Semester)

| Semester VII | | | | | | | | | |
|--------------|---------------|---------------------------------------|--------------|---|---|------------------|---|----|--|
| Type | Code | Course Title | WCH L-T-P | | | Credits L-T-P | | | |
| THEORY | | | | | | | | | |
| OO | | MOOC - I | 0 | 0 | 0 | 3 | 0 | 0 | |
| PRACTICAL | | | | | | | | | |
| PS | BTII-P-PS-004 | Practice School / Industry Internship | 0 | 0 | 0 | 0 | 0 | 16 | |
| PJ | BTII-P-PJ-003 | Summer Internship - III | 0 | 0 | 0 | 0 | 0 | 1 | |
| | | SUB-TOTAL | 0 | 0 | 0 | 3 | 0 | 17 | |
| | | TOTAL | 0 | | | 20 | | | |

| Semester VIII | | | | | | | | |
|---------------|----------------------------------|---|--------------|---|---|------------------|---|---|
| Type | Code | Course Title | WCH L-T-P | | | Credits L-T-P | | |
| THEORY | | | | | | | | |
| PE | | Professional Elective - IV | 3 | 0 | 0 | 3 | 0 | 0 |
| OE | | Open Elective - IV | 3 | 0 | 0 | 3 | 0 | 0 |
| OO | | MOOC - II | 0 | 0 | 0 | 3 | 0 | 0 |
| PRACTICAL | | | | | | | | |
| PE | BTEC-P-PE-023 / BTBS-P-PE-024 | Emerging Technologies Lab / Entrepreneurship Project | 0 | 0 | 4 | 0 | 0 | 2 |
| VV | BTEC-P-VV-028 | Comprehensive Viva | 0 | 0 | 0 | 0 | 0 | 1 |
| | | <i>SUB-TOTAL</i> | 6 | 0 | 4 | 9 | 0 | 3 |
| | | <i>TOTAL</i> | 10 | | | 12 | | |

| | | | | | | | | | |
|--|--|----------------------------------|------------|--|--|------------|--|--|--|
| | | GRAND TOTAL (8 SEMESTERS) | 175 | | | 162 | | | |
|--|--|----------------------------------|------------|--|--|------------|--|--|--|

Note:

1. Approved list of courses for MOOC-I & II (self study) shall be published by the department.
2. Courses offered under each elective are given in "List of Electives" on Page 222.

Curriculum Structure (PS-8)
(For Students opting for Practice School / Industry Internship in the 8th Semester)

| Semester VII | | | | | | | | | |
|--------------|----------------------------------|---|--------------|---|---|------------------|---|---|--|
| Type | Code | Course Title | WCH L-T-P | | | Credits L-T-P | | | |
| THEORY | | | | | | | | | |
| PE | | Professional Elective - IV | 3 | 0 | 0 | 3 | 0 | 0 | |
| OE | | Open Elective - IV | 3 | 0 | 0 | 3 | 0 | 0 | |
| OO | | MOOC - I | 0 | 0 | 0 | 3 | 0 | 0 | |
| PRACTICAL | | | | | | | | | |
| PE | BTEC-P-PE-023 / BTBS-P-PE-024 | Emerging Technologies Lab / Entrepreneurship Project | 0 | 0 | 4 | 0 | 0 | 2 | |
| PJ | BTII-P-PJ-003 | Summer Internship - III | 0 | 0 | 0 | 0 | 0 | 1 | |
| | | SUB-TOTAL | 6 | 0 | 4 | 9 | 0 | 3 | |
| | | TOTAL | 10 | | | 12 | | | |

| Semester VIII | | | | | | | | | |
|---------------|---------------|---------------------------------------|--------------|---|---|------------------|---|----|--|
| Type | Code | Course Title | WCH L-T-P | | | Credits L-T-P | | | |
| THEORY | | | | | | | | | |
| OO | | MOOC - II | 0 | 0 | 0 | 3 | 0 | 0 | |
| PRACTICAL | | | | | | | | | |
| PS | BTII-P-PS-004 | Practice School / Industry Internship | 0 | 0 | 0 | 0 | 0 | 16 | |
| VV | BTEC-P-VV-028 | Comprehensive Viva | 0 | 0 | 0 | 0 | 0 | 1 | |
| | | SUB-TOTAL | 0 | 0 | 0 | 3 | 0 | 17 | |
| | | TOTAL | 0 | | | 20 | | | |

| | | | | | | | | | |
|--|--|----------------------------------|------------|--|--|------------|--|--|--|
| | | GRAND TOTAL (8 SEMESTERS) | 175 | | | 162 | | | |
|--|--|----------------------------------|------------|--|--|------------|--|--|--|

Note:

1. Approved list of courses for MOOC-I & II (self study) shall be published by the department.
2. Courses offered under each elective are given in "List of Electives" on Page 222.

List of Electives

| Code | Elective # and Subjects |
|-----------------------------------|--|
| Professional Elective - IV | |
| BTEC-T-PE-047 | Speech & Audio Processing |
| BTEC-T-PE-048 | Mobile Communication & Networks |
| BTEC-T-PE-049 | Embedded System Design |
| Professional Elective - V | |
| BTEC-T-PE-057 | Antennas & Wave Propagation |
| BTEC-T-PE-051 | Wireless Sensor Networks |
| BTEC-T-PE-052 | Adaptive Signal Processing |
| BTEI-T-PE-023 | MEMS & Sensor Design |
| Professional Elective - VI | |
| BTEC-T-PE-053 | Mixed Signal Design |
| BTEC-T-PE-054 | Satellite Communication Systems |
| BTEI-T-PE-016 | Bio-Medical Electronics |
| Open Elective - IV | |
| BTEE-T-OE-035 | [EEE] Energy Studies |
| BTBS-T-OE-033 | [BSH] Simulation & Modeling |
| BTBS-T-OE-032 | [BSH] Project Management |
| BTCS-T-OE-043 | [CSE] Artificial Intelligence |
| BTCS-T-OE-044 | [CSE] Introduction to Machine Learning |
| BTEI-T-OE-022 | [EIE] Industrial Instrumentation |

Note: *Open Electives* are choice-based courses offered by other departments as indicated within brackets.

| Type | Code | Speech & Audio Processing | L-T-P | Credits | Marks |
|------|---------------|---------------------------|-------|---------|-------|
| PE | BTEC-T-PE-047 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to study the properties & quality of speech signals, and their processing like separation, recognition, coding, synthesis etc., for wireless communication. |
| Pre-Requisites | Basic knowledge about digital signal processing is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT, audio & video tools as required; sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Introduction: Speech production and modeling, Human auditory system; General structure of speech coders; Classification of speech coding techniques – parametric, waveform and hybrid; Requirements of speech codecs – quality, coding delays, robustness. | 8 Hours |
| Module-2 | Speech Signal Processing: Pitch-period estimation, All-pole and All-zero filters, convolution; Power spectral density, Periodogram, Autoregressive model, Autocorrelation estimation. | 8 Hours |
| Module-3 | Linear Prediction of Speech: Basic concepts of Linear Prediction, Linear Prediction Analysis of non-stationary signals – prediction gain, examples; Levinson-Durbin algorithm, Long term and short-term linear prediction models, Moving average prediction; Speech Quantization: Scalar quantization – uniform quantizer, optimum quantizer, logarithmic quantizer, adaptive quantizer, differential quantizers; Vector quantization – distortion measures, codebook design, codebook types. | 9 Hours |
| Module-4 | Scalar Quantization of LPC: Spectral distortion measures, Quantization based on reflection coefficient and log area ratio, bit allocation; Linear Prediction Coding - LPC model of speech production, Structures of LPC encoders and decoders, Voicing detection, Limitations of the LPC model. | 9 Hours |
| Module-5 | Code Excited Linear Prediction: CELP speech production model, Analysis-by-synthesis, Generic CELP encoders and decoders, Excitation codebook search – state-save method, CELP based on adaptive codebook, Adaptive codebook search, Low delay CELP and algebraic CELP. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. A. M. Kondoz, *Digital Speech*, 2nd Edition, Wiley Students Edition, 2004.
- T2. W. C. Chu, *Speech Coding Algorithms: Foundation & Evolution of Standardized Coders*, Wiley Inter Science, 2003.

Reference Books:

- R1. L. Rabiner, B. -H. Juang, and B. Yegnanarayana, *Fundamentals of Speech Recognition*, 1st Edition, Pearson Education, 2009.

R2. D. O. Shaughnessy, *Speech Communications - Human and Machine*, 2nd Edition, IEEE Press, 2012.

Online Resources:

1. <https://nptel.ac.in/courses/117105145/>: by Prof. S. K. D. Mandal, IIT Kharagpur
2. https://www.ece.ucsb.edu/Faculty/Rabiner/ece259/digital%20speech%20processing%20course/lectures_new/Lecture_algorithms_fall_2010.pdf

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

| | |
|-----|---|
| CO1 | Explain different speech production systems, coding techniques, and codecs. |
| CO2 | Describe pitch and power of speech signals and processing of the same. |
| CO3 | Visualize linear prediction methods and different types of quantizers for speech signals. |
| CO4 | Describe the LPC model and the structure of encoders & decoders. |
| CO5 | Analyze and synthesize CELP speech production model. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO7 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Mobile Communication & Networks | L-T-P | Credits | Marks |
|------|---------------|---------------------------------|-------|---------|-------|
| PE | BTEC-T-PE-048 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objectives of this course is to study the concepts of communication networks, wireless communication with its challenges & developments, wireless application protocols & standards, and Bluetooth technology. |
| Pre-Requisites | Basic knowledge of computer networking & wireless transmission is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on examples and latest trends. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Communication Networks: LANs, MANs, WANs, Switching techniques, Wireless ATM networks, TCP/IP protocol architecture, OSI protocol architecture, Internetworking. | 8 Hours |
| Module-2 | Wireless Communication Technology: Propagation modes, LOS transmission, Fading in the mobile environment, Free-space Attenuation, Attenuation over Reflecting Surfaces, Radio wave Propagation, Propagation Path-loss Models, Cost 231 Model. | 8 Hours |
| Module-3 | Cellular Wireless Networks: Principles of cellular network, first, second and third Generation systems; Multiple Access Technologies: Basic features of FDMA, TDMA, and CDMA, Mobile IP and wireless Access Protocol: Mobile IP, Wireless Application Protocol, Internet control message protocol, Message authentication, Service primitives and parameters. | 9 Hours |
| Module-4 | Wireless LAN Technology: Overview, Infrared LANs, Spread spectrum LANs, Narrowband microwave LANs. IEEE 802.11 Wireless LAN: IEEE 802 protocol architecture, IEEE 802.11 architecture and services, IEEE 802.11 MAC, IEEE 802.11 physical layer. | 9 Hours |
| Module-5 | Bluetooth: Overview, Radio specification, baseband specification, Link manager specification, Logical Link control and adaptation protocol; Wi-MAX standards, Wi-Fi standards, Zig-bee. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. U. Dalal, *Wireless Communication and Networks*, 1st Edition, Oxford University Press, 2015.
- T2. I. S. Misra, *Wireless Communication and Networks: 3G and Beyond*, 2nd Edition, McGraw-Hill Education, 2017.

Reference Books:

- R1. V. K. Garg, *Wireless Communication and Networking: Essential Reading*, Morgan Kaufman, 2008.
- R2. T. S. Rappaport, *Wireless Communications*, 2nd Edition, Pearson Education, 2010.
- R3. D. Tse and P. Viswanath, *Fundamentals of Wireless Communication*, Cambridge University Press, 2005.

Online Resources:

1. <https://nptel.ac.in/courses/106/105/106105082/>: by Prof. A. Pal, IIT Kharagpur
2. <https://nptel.ac.in/courses/106/108/106108098/>: by Prof. H.S. Jamadagni, IISc Bangalore
3. <https://nptel.ac.in/courses/106/105/106105081/>: by Prof. S. Ghosh, IIT Kharagpur
4. <https://nptel.ac.in/courses/106/105/106105183/>: by Prof. S. Chakraborty and Prof. S. K. Ghosh, IIT Kharagpur

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

| | |
|-----|---|
| CO1 | Explain the fundamentals of mobile communication networks and various protocols. |
| CO2 | Analyze radio propagation, fading, attenuation, channel modeling and other path losses. |
| CO3 | Explain & compare various wireless application protocols & mobile IP implementations. |
| CO4 | Explain the technical features of IEEE wireless LAN standard. |
| CO5 | Describe the technical details of different IEEE wireless communication protocols. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Embedded System Design | L-T-P | Credits | Marks |
|------|---------------|------------------------|-------|---------|-------|
| PE | BTEC-T-PE-049 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to study the components, programming, integration, and life cycle management of hardware & firmware to design & develop embedded systems for real-world applications. |
| Pre-Requisites | Knowledge of microprocessor & microcontrollers, basic electronics, digital electronic circuits and operating systems is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Introduction: Embedded Systems, Processor embedded into a system, Embedded hardware units and devices, Embedded software, Examples, Embedded SoC and use of VLSI, Design process and examples, Classification of embedded systems, Skills required for a designer; Typical Embedded System: Core, Memory, Sensors & Actuators, Communication interface, Embedded firmware. | 8 Hours |
| Module-2 | Characteristic & Quality Attributes: Application and domain specific embedded systems; Designing with Microcontrollers, Factors to consider for selecting a controller; Hardware Software Co-Design and Program Modeling: Fundamental issues in Hardware Software Co-Design, Computational models in embedded design, Introduction to UML, Hardware Software Trade-offs. | 9 Hours |
| Module-3 | Embedded Hardware Design & Development: Analog Electronic Components, Digital Electronic Components, VLSI and Integrated Circuit Design, Electronic Design Automation (EDA) Tools; Embedded Firmware Design & Development: Design Approaches, Development Languages. | 8 Hours |
| Module-4 | Real Time Operating System (RTOS) based Design: Operating system basics, Types of operating systems, Tasks, Process & Threads, Multiprocessing & Multitasking, Task Scheduling, Task Communication, Task Synchronization, Choosing an RTOS. | 8 Hours |
| Module-5 | Integration & Testing: Integration of Hardware & Firmware, Board Power up; Embedded System Development Environment: Integrated Development Environment (IDE), Types of files generated on cross-compilation, Disassembler/Decompiler, Simulators, Emulators & Debugging, Target Hardware Debugging; Product Enclosure Design & Development: Tools, Development Techniques, Embedded Product Development Life Cycle (EDLC): Definition and Objectives of EDLC, Phases of EDLC, EDLC Approaches (Modeling the EDLC). | 9 Hours |
| Total | | 42 Hours |

Text Books:

- T1. K. V. Shibu, *Introduction to Embedded Systems*, 1st Edition, Tata McGraw-Hill, 2009.
 T2. R. Kamal, *Embedded Systems – Architecture, Programming and Design*, 12th Edition, Tata McGraw-Hill, 2007.

Reference Books:

- R1. D. E. Simon, *An Embedded Software Primer*, 1st Edition, Addison Wesley, 1999.
 R2. J. Ganssle, *The Art of Designing Embedded Systems*, 2nd Edition, Elsevier, 2008.
 R3. K. Short, *Embedded Microprocessor System Design*, 1st Edition, Prentice Hall, 1998.
 R4. C. Baron, J. Geffroy, and G. Motet (Eds), *Embedded System Applications*, Springer, 1997.
 R5. D. Gajski, *Embedded System Design: Modeling, Synthesis and Verification*, Springer, 2009.

Online Resources:

1. <https://nptel.ac.in/courses/106105159/>: by Prof. A. Basu, IIT Kharagpur
 2. <https://nptel.ac.in/courses/108102045/>: by Prof. S. Chaudhary, IIT Delhi

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

| | |
|-----|---|
| CO1 | Describe the fundamental building blocks of a typical embedded system. |
| CO2 | Explain the quality attributes of embedded systems and the co-design approach for embedded hardware and firmware development. |
| CO3 | Explain the elements of embedded hardware and their design principles and development steps. |
| CO4 | Understand the need for an operating system and internals of RTOS based embedded firmware design. |
| CO5 | Integrate, test, and manage an embedded system development life cycle (EDLC). |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |

Cont'd...

| | |
|------|--|
| PO7 | 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. |
| PO10 | 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. |
| PO11 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Antennas & Wave Propagation | L-T-P | Credits | Marks |
|------|---------------|-----------------------------|-------|---------|-------|
| PE | BTEC-T-PE-057 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to study the principle of electromagnetic radiation, different types of antennas with their working principles and wave propagation characteristics. |
| Pre-Requisites | Knowledge of network theory and electro-magnetic theory is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as needed; sessions are planned to be interactive with focus on working principle of different antennas. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Fundamental Parameters of Antennas: Radiation pattern, Beam solid angle, Directivity, Gain, Input impedance, Polarization, Bandwidth, Reciprocity, Equivalence of Radiation patterns, Equivalence of Impedances, Effective aperture, Vector effective length, Antenna temperature. | 8 Hours |
| Module-2 | Electromagnetic Radiation: Review of electromagnetic theory - Vector potential, Solution of wave equation, Retarded case, Hertzian dipole. | 8 Hours |
| Module-3 | Wire Antennas: Short dipole, Radiation resistance and Directivity, Half Wave Dipole, Monopole, Small loop antennas; Antenna Arrays: Linear Array and Pattern Multiplication, Two-element Array, Uniform Array, Polynomial representation, Array with non-uniform Excitation - Binomial Array. | 9 Hours |
| Module-4 | Aperture Antennas: Magnetic current and its fields, Uniqueness theorem, Field equivalence principle, Duality principle, Method of Images, Pattern properties, Slot antenna, Horn antenna, Pyramidal horn antenna, Reflector antennas - Flat reflector, Corner reflector, Common curved reflector shapes, Lens antenna. | 8 Hours |
| Module-5 | Special Antennas: Long wire, V and Rhombic antenna, Yagi-Uda antenna, Turnstile antenna, Helical antennas - Axial mode helix, Normal mode helix, Biconical antenna, Log periodic dipole array, Spiral antenna, Microstrip patch antennas. Antenna Measurements: Radiation pattern measurement, Gain and directivity measurements, Anechoic chamber measurement. | 9 Hours |
| Total | | 42 Hours |

Text Books:

- T1. C. A. Balanis, *Antenna Theory : Analysis and Design*, 4th Edition, John Wiley & Sons, 2016.
- T2. A. R. Harish and M. Sachidanada, *Antennas and Wave Propagation*, 1st Edition, Oxford University Press, 2007.

Reference Books:

- R1. J. D. Kraus, R. J. Marhefka, and A. S. Khan, *Antennas for All Applications*, 3rd Edition, Tata McGraw-Hill, 2002.

- R2. R. C. Johnson and H. Jasik, *Antenna Engineering Hand Book*, 3rd Edition, McGraw-Hill, 1993.
 R3. I. J. Bhal and P. Bhartia, *Micro-strip Antennas*, 2nd Edition, Artech House, 1980.

Online Resources:

1. <https://nptel.ac.in/courses/108/105/108105114/>: by Dr. A. Bhattacharya, IIT Kharagpur
2. <https://nptel.ac.in/courses/108/101/108101092/>: by Prof. G. Kumar, IIT Bombay
3. <https://nptel.ac.in/courses/117/107/117107035/>: Dr. A. Patnaik, IIT Roorkee
4. <https://nptel.ac.in/content/storage2/courses/108101092/Antennas-Course-Outline-16Aug2016.pdf>: Slides by Prof. G. Kumar, IIT Bombay

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

| | |
|-----|---|
| CO1 | Explain fundamental parameters of antennas and their implications. |
| CO2 | Formulate mathematical model for electric & magnetic fields of various antennas. |
| CO3 | Design antenna arrays and analyze their radiation patterns. |
| CO4 | Describe principles & radiation mechanisms of various antennas with their applications. |
| CO5 | Measure the antenna parameters and describe features of special antennas. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Wireless Sensor Networks | L-T-P | Credits | Marks |
|------|---------------|--------------------------|-------|---------|-------|
| PE | BTEC-T-PE-051 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to study the concepts of wireless sensor networks with their architecture, design principles, protocols, and practical challenges along with localization and positioning techniques. |
| Pre-Requisites | Basic knowledge of wireless communication is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on examples and practical applications. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Sensor Network Concept: Introduction, Networked wireless sensor devices, Advantages of Sensor networks, Applications, Key design challenges. | 6 Hours |
| Module-2 | Network Deployment: Structured versus randomized deployment, Network topology, Connectivity, Connectivity using power control, Coverage metrics, Mobile deployment. | 8 Hours |
| Module-3 | Localization and Tracking: Issues and approaches, Problem formulations - Sensing model, collaborative localization, Coarse-grained and Fine-grained node localization, Tracking multiple objects. | 10 Hours |
| Module-4 | Wireless Communications: Link quality, shadowing and fading effects. Medium-access & Sleep Scheduling: Traditional MAC protocols, Energy efficiency in MAC protocols, Asynchronous sleep techniques, Sleep-scheduled techniques, and Contention-free protocols. | 10 Hours |
| Module-5 | Routing: Metric-based approaches, Multi-path routing, Lifetime-maximizing energy-aware routing techniques, Geographic routing. Sensor Network Databases: Data-centric routing, Data-gathering with compression. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. F. Zhao and L. Guibas, *Wireless Sensor Networks: An Information Processing Approach*, 3rd Edition, Morgan Kaufmann, 2004.

Reference Books:

- R1. B. Krisnamachari, *Networking Wireless Sensors*, 1st Edition, Cambridge University Press, 2005.
 R2. C. S. Raghavendr, M. K. Sivalingam, and T. Znati, *Wireless Sensor Networks*, 1st Edition, Springer, 2006.
 R3. K. Sohraby, D. Minoli, and T. Znati, *Wireless Sensor Networks: Technology, Protocols, and Applications*, 1st Edition, Wiley Inter Science, 2010..

Online Resources:

1. <https://nptel.ac.in/courses/106/105/106105160/>: by Prof. S. Misra, IIT Kharagpur

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

| | |
|-----|---|
| CO1 | Explain sensing, computing and communication tasks of wireless sensor networks. |
| CO2 | Deploy wireless sensors and design communication protocols in WSNs. |
| CO3 | Analyze localization and tracking issues in wireless sensor networks. |
| CO4 | Explain the concepts of MAC layer protocols for WSNs. |
| CO5 | Compare various WSN routing techniques and their implications. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Adaptive Signal Processing | L-T-P | Credits | Marks |
|------|---------------|----------------------------|-------|---------|-------|
| PE | BTEC-T-PE-052 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to study the theory of adaptive systems, recursive & non-recursive algorithms for different adaptive problems, and their applications to adaptive systems. |
| Pre-Requisites | Basic knowledge of mathematics, trigonometry, probability & statistics, and signals & systems is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Introduction: Adaptive Systems – Definition and characteristics, General properties, Open and Closed Loop Adaptations, Applications. | 7 Hours |
| Module-2 | The Adaptive Linear Combiner: Performance function, Gradient and Mean Square Error, Examples. Theory of Adaptation with Stationary Signals: Properties of the Quadratic Performance Surface, Significance of eigen values, eigen vectors, correlation matrix. | 9 Hours |
| Module-3 | Searching the Performance Surface: A simple gradient search algorithm, Stability and Rate of convergence, the learning curve. Gradient Estimation and its Effects on Adoption: The performance penalty, Variance of the gradient estimate, Maladjustment. | 9 Hours |
| Module-4 | Adaptive Algorithms and Structures: The LMS Algorithm, Convergence, learning Curve, Performance analysis, Filtered X LMS algorithm. | 8 Hours |
| Module-5 | Applications: Adaptive Modeling and System Identification using adaptive filter, Inverse Adaptive Modeling, De-convolution, and equalization using adaptive filter. | 9 Hours |
| Total | | 42 Hours |

Text Books:

T1. B. Widrow and S. D. Stearns, *Adaptive Signal Processing*, 2nd Edition, Pearson Education, 2009.

Reference Books:

R1. S. Haykin, *Adaptive Filter Theory*, 4th Edition, Pearson Education, 2008.

Online Resources:

1. <https://nptel.ac.in/courses/117/105/117105075/>: by Prof. M. Chakraborty, IIT Kharagpur

P.T.O

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

| | |
|-----|--|
| CO1 | Use probability theory to comprehend design criteria and model adaptive systems. |
| CO2 | Develop mathematical model of linear adaptive processors for performance & stability. |
| CO3 | Use gradient search algorithm for gradient estimation for adaptive systems. |
| CO4 | Apply LMS algorithm for estimating the filter weight & performance analysis. |
| CO5 | Apply various filtering techniques to a given problem and assess the solution & results. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO7 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | MEMS & Sensor Design | L-T-P | Credits | Marks |
|------|---------------|----------------------|-------|---------|-------|
| PE | BTEI-T-PE-019 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to study the underlying principles of microsystems, advantages of miniaturization, fundamentals of micro-machining and micro-fabrication techniques for designing right type of miniaturized sensors & instruments in different applications. |
| Pre-Requisites | Fundamental knowledge of sensors and transducers is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on examples & case studies. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Overview of MEMS & Microsystems: Introduction, MEMS products, Difference between Microsystems and Microelectronics, Multidisciplinary approach of MEMS, automotive and other industrial applications, Markets of Microsystems; Materials for MEMS: Substrate and Wafers, Active substrate materials, Silicon as substrate, compound, and piezoresistive materials, GaAs, Quartz, PZT, Polymers, Packaging materials. | 8 Hours |
| Module-2 | Microsystem Fabrication Process: Introduction, Photolithography, Ion implantation, Diffusion, Oxidation, CVD, PVD, Sputtering, deposition by Epitaxy, Wet etching of silicon: Isotropic etching, Anisotropic etching, TMAH, EDP; Micromanufacturing: Bulk Micromachining, Surface Micromachining, LIGA. | 8 Hours |
| Module-3 | MEMS for Sensing & Actuation: Microsensors: Acoustic wave, Biosensors, Chemical, Optical, Pressure, Thermal sensors; Microactuation: Thermal forces, SMA, Piezoelectric crystals and Electrostatic forces; Concepts of Microgrippers, Micromotors, Microvalves and Micropumps, Microaccelerometers, Microfluidics. | 10 Hours |
| Module-4 | Microsystems Design: Introduction, Design Considerations, Process Design, Mechanical Design, Finite Element Method, Design of a Micropressure Sensor, Design of Microfluidics Network Systems, Computer-Aided Design; Design Considerations of Piezoresistive Pressure Sensor, Inertial Sensor, Tactile Sensor, Flow Sensor. | 9 Hours |
| Module-5 | Selected MEMS Products: Blood Pressure (BP) Sensor, Microphone, Acceleration Sensors, Gyro and its design considerations; Top Concerns of MEMS Products: Performance, Accuracy, Repeatability, Reliability, Cost and Market Uncertainties. | 7 Hours |
| Total | | 42 Hours |

Text Books:

- T1. T. -R. Hsu, *MEMS & Microsystems - Design and Manufacture*, 1st Edition, McGraw-Hill Education, 2017.

T2. C. Liu, *Foundations of MEMS*, 2nd Edition, Pearson Education, 2012.

Reference Books:

- R1. S. E. Lyshevski, *Nano- and Micro-Electromechanical Systems : Fundamentals of Nano- and Microengineering (Vol. 8)*, CRC Press, 2005.
- R2. D. A. Bell, *Electronic Instrumentation and Measurements*, 2nd Edition, Oxford University Press, 2007.
- R3. G. K. Ananthasuresh, K. J. Vinoy, S. Gopalkrishnan, K. N. Bhat, and V. K. Aatre, *Micro and Smart Systems*, 1st Edition, Wiley India, 2012.
- R4. E. Gaura and R. M. Newman, *Smart MEMS and Sensor Systems*, 1st Edition, Imperial College Press, 2006.

Online Resources:

1. <https://nptel.ac.in/courses/108/108/108108113/>: by Prof. H. J. Pandya, IISc Bangalore
2. <https://nptel.ac.in/courses/117/105/117105082/>: by Prof. S. Kal, IIT Kharagpur
3. <https://nptel.ac.in/courses/112/104/112104181/>: by Dr. S. Bhattacharya, IIT Kanpur

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

| | |
|-----|--|
| CO1 | Recall various materials & techniques used for micromachining. |
| CO2 | Explain the fabrication technologies used in microsystem design. |
| CO3 | Elaborate on different design concepts of MEMS for sensing and actuation. |
| CO4 | Analyze the design considerations of Microsystems design for different types of sensors. |
| CO5 | Design advanced MEMS sensors and explain the design considerations using case studies. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Mixed Signal Design | L-T-P | Credits | Marks |
|------|---------------|---------------------|-------|---------|-------|
| PE | BTEC-T-PE-053 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to study the inter-conversion of analog & digital signals, design of systems involving mixed signals, and their practical applications in various fields. |
| Pre-Requisites | Basic knowledge of signal processing, and analog & digital communication techniques is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Analog & Discrete-time Signal Processing: Introduction to sampling theory; Time Domain Description of Reconstruction, The Sample-and-Hold (S/H) Spectral Response, The Reconstruction Filter (RCF); Analog Continuous Time Filters: Passive and Active Filters; Basics of Analog Discrete-time Filters. | 9 Hours |
| Module-2 | Switched-Capacitor Filters: Nonidealities in switched-capacitor filters; Switched-capacitor filter architectures; Switched-capacitor filter applications. | 8 Hours |
| Module-3 | Analog to Digital Converters: Basics of data converters, Successive approximation ADCs, Dual slope ADCs, Flash ADCs, Pipeline ADCs, DACs. | 9 Hours |
| Module-4 | Mixed-signal Layout: Interconnects and data transmission; Voltage-mode signalling and data transmission; Current-mode signaling and data transmission. | 8 Hours |
| Module-5 | Frequency Synthesizers & Synchronization: Basics of PLL, Analog PLLs; Digital PLLs; DLLs. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. R. J. Baker, *CMOS Mixed-Signal Circuit Design*, Wiley India, IEEE Press, 2008.
- T2. B. Razavi, *Design of Analog CMOS Integrated Circuits*, 1st Edition, McGraw-Hill Education, 2003.

Reference Books:

- R1. R. V. dePlassche, *CMOS Integrated ADCs and DACs*, Indian Edition, Springer, 2005.
- R2. A. B. Williams, *Electronic Filter Design Handbook*, McGraw-Hill Education, 1981.
- R3. R. Schaumann and M. E. V. Valkenburg, *Design of Analog Filters*, Oxford University Press, 2008.
- R4. R. J. Baker, *CMOS Circuit Design: Layout and Simulation*, 2nd Rev. Edition, IEEE Press, 2008.

P.T.O

Online Resources:

1. <https://nptel.ac.in/courses/117105143/>
2. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/117105143/lec60.pdf
3. <http://www.digimat.in/nptel/courses/video/117105143/L22.html>
4. <http://www.nptelvideos.in/2012/11/communication-engineering.html>

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

| | |
|-----|---|
| CO1 | Apply various techniques for processing of analog and discrete-time signals. |
| CO2 | Design switched-capacitor filters for various mixed-signal applications. |
| CO3 | Convert analog signals to digital form and vice versa. |
| CO4 | Describe voltage and current mode signaling and data transmission in mixed-signal layout. |
| CO5 | Differentiate between various types frequency synthesizers. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO7 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Satellite Communication Systems | L-T-P | Credits | Marks |
|------|---------------|---------------------------------|-------|---------|-------|
| PE | BTEC-T-PE-054 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to study modern satellite based communication systems for designing different downlinks, uplinks, along with preparation of link budgets to avoid signal outage for effective communications via satellites. |
| Pre-Requisites | Basics of analog & digital communication, and microwaves are required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Architecture: Principles and architecture of satellite communication, Brief history, advantages, disadvantages, applications, and frequency bands used for satellite communication. Orbital Analysis: Orbital equations, Kepler's laws of planetary motion, Apogee and Perigee for an elliptical orbit, evaluation of velocity, orbital period, angular velocity etc., of a satellite, Locating satellites with respect to earth, Look angles determination. | 9 Hours |
| Module-2 | Satellite Sub-systems: Architecture and roles of various sub-systems of a satellite system such as telemetry, tracking, command, and monitoring (TTC & M), Altitude and orbit control system (AOCS), Communication sub-system, Power sub-systems, Antenna sub-system, Equipment reliability, and space qualifications. | 8 Hours |
| Module-3 | Typical Phenomena in Satellite Communication: Solar Eclipse on satellite, its effects, remedies for Eclipse, Sun Transit Outage phenomena, its effects and remedies, Doppler frequency shift phenomena and expression for Doppler shift, Range variations and remedies, orbital perturbations. | 8 Hours |
| Module-4 | Satellite Link Budget: Flux density and received signal power equations, Calculation of System noise temperature for satellite receiver, noise power calculation, Drafting of satellite link budget and C/N ratio calculations in clear air and rainy conditions, Case study of Personal Communication system (satellite telephony) using LEO. | 9 Hours |
| Module-5 | Modulation and Multiple Accessing Techniques: Analog FM transmission by satellite, Digital transmission, TDM, FDMA, TDMA, CDMA, Typical case studies of VSAT, DBS-TV satellites, GPS. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. T. Pratt, C. Bostian, and J. Allnutt, *Satellite Communications*, 2nd Edition, Wiley India, 2010.
- T2. W. L. Pritchard, H. G. Suyderhoud, and R. A. Nelson, *Satellite Communication Systems Engineering*, Pearson Education, 2003.

Reference Books:

- R1. T. T. Ha, *Digital Satellite Communications*, 2nd Edition, Tata McGraw-Hill, 2009.
 R2. D. Roddy, *Satellite Communications*, 4th Edition, Tata McGraw-Hill, 2008.
 R3. A. K. Maini and V. Agrawal, *Satellite Communications*, Wiley, 2019.

Online Resources:

1. <https://nptel.ac.in/courses/117/105/117105131/>: by Prof. K. Bandyopadhyay, IIT Kharagpur
2. <https://nptel.ac.in/courses/101/105/101105077/>: by Dr. M. Sinha, IIT Kharagpur
3. <https://nptel.ac.in/courses/105/107/105107194/>: by Prof. A. K. Saraf, IIT Roorkee

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

| | |
|-----|---|
| CO1 | Describe the fundamentals and orbital mechanics of satellite communication systems. |
| CO2 | Explain different satellite subsystems for effective communication. |
| CO3 | Analyze and solve problems related to orbital effects of satellites. |
| CO4 | Optimize practical satellite links considering various atmospheric propagation effects. |
| CO5 | Analyze and optimize different modulation and MAC techniques in case studies. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Bio-Medical Electronics | L-T-P | Credits | Marks |
|------|---------------|-------------------------|-------|---------|-------|
| PE | BTEI-T-PE-016 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to study different biomedical instruments, sensors, signal processing techniques, and their application in diagnosis, therapeutic and surgical procedures. |
| Pre-Requisites | Knowledge of basic electronics, sensors, and transducers are required. |
| Teaching Scheme | Regular classroom lectures with use of ICT, audio & video tools as required; sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Introduction to Bio-Engineering: Bio-medical signals – sources & examples, Basic medical instrumentation system, Use of microprocessors, Design constraints; Bio-electric potentials: Sources, resting & action potentials; Biomedical Signals: Anatomy of heart, ECG, PCG, EEG, EMG. | 9 Hours |
| Module-2 | Biomedical Electrodes and Recorders: Electrode theory, Recording electrodes, Bio-potential electrodes for ECG, EEG and EMG, Microelectrodes, ECG recorder, Sources of artifacts in ECG and their removal methods, EEG & EMG recorder. | 8 Hours |
| Module-3 | Patient Care Monitoring: System concepts, Measurement of heart rate, Measurement of pulse rate, Types of blood pressure and blood flow measurement. | 8 Hours |
| Module-4 | X-Ray and Radioisotope Instrumentation: Generation of ionizing radiation, Nature and production of X-Rays, Computed Tomography, Magnetic Resonance Imaging system, Ultrasonic imaging systems. | 8 Hours |
| Module-5 | Bio Sensors: Basic transducer principles – Transducer and Transduction principles, Classification of transducers, Transducers for Biomedical applications, Glucose sensors, Immune sensors, MOSFET biosensors & BIOMEMS and Smart sensors. | 9 Hours |
| Total | | 42 Hours |

Text Books:

- T1. R. S. Khandpur, *Handbook of Biomedical Instrumentation*, 3rd Edition, McGraw Hill Education, 2014.
- T2. D. C. Reddy, *Biomedical Signal processing - Principles & Techniques*, 1st Edition, Tata McGraw Hill, 2005.
- T3. R. M. Rangayyan, *Biomedical Signal Analysis - A case Study Approach*, 2nd Edition, John Wiley & Sons, 2002.

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Reference Books:

- R1. J. L. Cromwell, F. J. Weibell, and E. A. Pfeiffer, *Biomedical Instrumentation and Measurement*, 2nd Edition, Prentice Hall of India, 2017.
- R2. J. J. Carr and J. M. Brown, *Introduction to Biomedical Equipment Technology*, 4th Edition, Pearson Education, 2000.
- R3. H. E. Thomas, *Handbook of Biomedical Instrumentation and Measurement*, 1st Edition, Reston Publishing Company, 1975.

Online Resources:

1. <https://nptel.ac.in/courses/102101068/>: by Prof. S. Srivastava, IIT Bombay
2. <https://nptel.ac.in/courses/108/105/108105101/>: by Prof. S. Mukhopadhyaya, IIT Kharagpur
3. <https://nptel.ac.in/courses/108/105/108105091/>: by Prof. D. Sheet, IIT Kharagpur
4. <https://ocw.mit.edu/courses/biological-engineering/>

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

| | |
|-----|--|
| CO1 | Explain the operating principles, design and applications of biomedical engineering. |
| CO2 | Describe human physiological system with respect to design consideration of medical equipment. |
| CO3 | Compare different medical recording and imaging systems and explain the limitations of pathological diagnosis. |
| CO4 | Realize the risk factors of different medical instruments and electrical safety parameters. |
| CO5 | Determine application of bio-sensors for biomedical signal processing in specific applications. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO7 | 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. |
| PO8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Energy Studies | L-T-P | Credits | Marks |
|------|---------------|----------------|-------|---------|-------|
| OE | BTEE-T-OE-035 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to study energy systems with emphasis on technologies & initiatives for renewable & alternative energy sources. |
| Pre-Requisites | General knowledge on physics, electricity, and environment is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on examples and case studies. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Sources of Energy: Conventional & non-conventional sources of energy, Fossil fuels, Nuclear fuels, hydel, solar, wind and bio fuels in India, Energy conservation, Nuclear energy through fission and fusion processes. | 8 Hours |
| Module-2 | Energy Conversion: Energy conversion routes, Direct and indirect ways of energy conversion, Basic conversion techniques for Solar, Nuclear, Geothermal, Tide and Wind Energies. | 8 Hours |
| Module-3 | Energy & Environment: Energy efficiency & conservation, Clean energy technologies, Importance in sustainable development, Greenhouse effect, Carbon footprint, Energy consumption & sustainability, Economics of energy, Economics of production versus consumption, Linkages between economic & environmental outcomes, Influence of economic, environmental, trade, and research policies on future energy. | 8 Hours |
| Module-4 | Global & Indian Energy Scenario: Role of energy in economic development & social transformation, Overall energy demand, Availability & consumption, Depletion of energy resources & its impact on economy, Nonproliferation of nuclear energy; International energy policies of G-8, G-20, OPEC and European union countries, Kyoto protocol, Paris convention & other initiatives; Indian Energy Scenario: Commercial & non-commercial forms of energy, Utilization pattern in the past & present, Future prediction, Sector-wise energy consumption, Indian Energy Policy & regulation, Energy policy issues at global level, National level and state level, Energy Conservation Act 2001, Restructuring of Indian power sector & Electricity Act 2003, Energy pricing & its impact on global variations, National solar mission. | 10 Hours |
| Module-5 | Energy Conservation: Fundamentals of energy conservation, Energy management in power plant, Energy conservation in buildings, Heating, Ventilation, Evaluation of heat loss, Heat gain in building systems & air-conditioning system, Degree day in energy use monitoring, Energy conservation opportunities in chemical industries, Waste heat recovery, Co-generation, Energy conservation in agricultural sector, Energy conservation in illumination engineering. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. G. Boyel, *Renewable Energy - Power for a Sustainable Future*, 3rd Edition, Oxford University Press, 2012.
- T2. R. A. Ristinen and J. P. Kraushaar, *Energy and the Environment*, 2nd Edition, John Wiley & Sons, 2006.
- T3. F. Kreith and D. Y. Goswami, *Energy Management and Conservation Handbook*, 1st Edition, CRC Press, 2017.

Reference Books:

- R1. S. A. Abbasi and N. Abbasi, *Renewable Energy Sources and Their Environmental Impact*, Pentice Hall of India, 2004.
- R2. D. R. Jalilvand and K. Westph, *The Political and Economic Challenges of Energy in the Middle East and North Africa*, 1st Edition, Routledge (Taylor & Francis Group), 2017.
- R3. J. Goldemberg, *World Energy Assessment: Energy and the Challenge of Sustainability*, United Nations, 2001.
- R4. B. H. Khan, *Non-Conventional Energy Resources*, 3rd Edition, Tata McGraw-Hill, 2017.

Online Resources:

1. https://en.wikipedia.org/wiki/Kyoto_Protocol
2. https://en.wikipedia.org/wiki/Paris_Agreement

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

| | |
|-----|---|
| CO1 | Identify various alternate energy sources and their characteristics. |
| CO2 | Analyze different energy conversion techniques for renewable energy systems. |
| CO3 | Evaluate the effect of energy consumption on environment, economy and development. |
| CO4 | Visualize global & national energy scenario and international energy policies. |
| CO5 | Investigate different energy conservation techniques and energy management systems. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO6 | 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. |
| PO7 | 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. |
| PO8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| PO12 | 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. |

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Simulation & Modelling | L-T-P | Credits | Marks |
|------|---------------|------------------------|-------|---------|-------|
| OE | BTBS-T-OE-033 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to learn the basic concepts and steps of statistical simulation along with some modeling problems for engineering, scientific, business, and social science processes in the real life. |
| Pre-Requisites | Basic knowledge of probability and statistics is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Basic concepts of Queue, M/M/1 and M/M/s queues, Queues involving non exponential distributions, Inventory models, Deterministic Continuous review model, Deterministic Periodic review model. | 8 Hours |
| Module-2 | Random number generation and its application to integration, Estimation of π and other problems, Generating discrete random variable: Inverse Transform Method, Generating geometric random variable and Bernoulli Random variable, Generating Poisson and Binomial random variable, The Acceptance Rejection method, The composition Approach, Programming for Generation of discrete random variable. | 9 Hours |
| Module-3 | Generation of Continuous random variable: The inverse transform method, The rejection Method, Generating Normal random variable by different methods, Generating Poisson Process, Simulating a single server queuing system, A queuing system with two servers in series, A queuing system with two servers in parallel, An inventory Model, An Insurance Risk model. | 10 Hours |
| Module-4 | Simulation of A Repair model, Programming for simulation model, Reduction of Variance using Antithetic variables, Estimation of system reliability using antithetic variables, Application Problems, Reduction of variance using Control Variates, Application Problems, Variance by conditioning, Application Problems. | 8 Hours |
| Module-5 | Stratified Sampling, Reduction of variance using stratified sampling, Goodness of Fit for Discrete Data, Kolmogorov-Smirnov Test for Continuous Data, Goodness of Fit test when some parameters are unspecified, Two sample problem. | 7 Hours |
| Total | | 42 Hours |

Text Books:

- T1. F. S. Hillier and G. J. Lieberman, *Introduction to Operations Research*, 8th Edition, McGraw-Hill, 2005.
- T2. S. M. Ross, *Simulation*, 5th Edition, Academic Press, 2012.

Reference Books:

- R1. A. M. Law and W. D. Kelton, *Simulation Modeling and Analysis*, 4th Edition, McGraw-Hill Higher Education, 2005, Online: <https://fac.ksu.edu.sa/sites/default/files/index.pdf>.
 R2. H. A. Taha, *Operations Research*, 8th Edition, Pearson Education, 2006.

Online Resources:

1. <https://nptel.ac.in/courses/110106062/>: by Prof. G. Srinivasan, IIT Madras
2. <https://nptel.ac.in/courses/111/107/111107128/>: by Prof. Kusumdeep, IIT Roorkee
3. <https://nptel.ac.in/courses/112/106/112106134/>: by Prof. G. Srinivasan, IIT Madras

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

| | |
|-----|---|
| CO1 | Understand the queue and inventory model and solve related problems. |
| CO2 | Create discrete random variable. |
| CO3 | Generate continuous random variable and simulate queues and inventory models. |
| CO4 | Understand and apply the variance reduction methods in simulation. |
| CO5 | Test the goodness of a simulation by analyzing the simulated data. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Project Management | L-T-P | Credits | Marks |
|------|---------------|--------------------|-------|---------|-------|
| OE | BTBS-T-OE-032 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this course is to study the fundamental tools and behavioral skills necessary to successfully launch, lead, and realize benefits, develop the skills for planning and controlling, and understanding key factors to drive successful project outcomes. |
| Pre-Requisites | General knowledge of any organization and its operations is sufficient. |
| Teaching Scheme | Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with real-life examples. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Objective of Project Management, Types of Projects, Project Life Cycle, project Initiation, project planning, Project Execution, Project closure; Analysis of a project: Market demand analysis, Technical analysis and financial estimation. | 9 Hours |
| Module-2 | Commonly used techniques for Project Management, Network techniques - PERT, CPM, Crashing of a project network, Line of balance (LOB): Application area of LOB, Input of LOB, Steps of LOB, Line balancing: Rank Positional weight method. Project Resource Management: Allocation, Leveling and Smoothing methods. | 9 Hours |
| Module-3 | Project Selection technique, Investment criteria (NPV, IRR, Benefit Cost Ratio), Project cash flows, Cost of capital, Risk analysis, Sources, Measures and perspectives of risk, Sensitivity analysis, Scenario analysis, Break-even analysis, Simulation analysis, Decision tree analysis, Managing risk, Project selection under risk. | 8 Hours |
| Module-4 | Project Financing, Capital structure, Sources of finance, internal accrual, securities, term loans, working capital, Equity and Debt, Venture capital and private equity. | 8 Hours |
| Module-5 | Social Cost Benefit Analysis (SCBA): Rationale for SCBA, UNIDO Approach, Net Benefit In terms of Economics (efficiency) Prices. Project Audit: Project failure & reasons for Audit, Phases of Project Audit. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. P. Chandra, *Projects Planning, Analysis, Selection, Financing, Implementation and Review*, 9th Edition, McGraw-Hill Education, 2019.
- T2. R. Paneerselvam and P. Senthilkumar, *Project Management*, 1st Edition, PHI Learning, 2009.

P.T.O

Reference Books:

- R1. C. Gray, E. Larson, and G. Desai, *Project Management The Managerial Process*, 7th Edition, McGraw Hill, 2013.
- R2. B. Punmia and K. Khandelwal, *Project Planning and Control with PERT and CPM*, 4th Edition, Laxmi Publications, 2006.

Online Resources:

1. <https://nptel.ac.in/courses/110/104/110104073/>: by Prof. R. Sengupta, IIT Kanpur
2. <https://nptel.ac.in/courses/110/107/110107081/>: by Prof. S. K. Gupta & Prof. M. K. Barua, IIT Roorkee

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

| | |
|-----|--|
| CO1 | Describe the fundamental project management tools and behavioral skills. |
| CO2 | Explain the basic concept of various network techniques for project management. |
| CO3 | Optimally utilize the resources for successful completion of a project. |
| CO4 | Perform cost-benefit analysis of a project considering various factors involved. |
| CO5 | Plan, monitor, control, and administer projects using computerized PMIS tools. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| PO9 | Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO11 | 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. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Artificial Intelligence | L-T-P | Credits | Marks |
|------|---------------|-------------------------|-------|---------|-------|
| OE | BTCS-T-OE-043 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of the course is to provide a strong foundation of fundamental concepts and goals, methods & techniques of Artificial Intelligence (AI) to build intelligent systems with perception, reasoning, and learning abilities. |
| Pre-Requisites | Knowledge of basic mathematics, algorithms & data structures is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Artificial Intelligence: Introduction; Intelligent Agents: Agents and Environment, Good Behavior, Nature of Environments, Structure of Agents; Problem Solving: Solving Problems by Searching - Problem-Solving Agents, Example Problems, Searching for Solutions, Uninformed search strategies, Searching with Partial Information. | 8 Hours |
| Module-2 | Informed Search & Exploration: Informed (Heuristic) search strategies, Heuristic functions, Local Search Algorithms & Optimization Problems; Constraint Satisfaction Problems: Introduction, Backtracking search for CSPs, Local Search for CSPs; Adversarial Search: Games, Optimal Decisions in Games, Alpha-Beta Pruning; Knowledge & Reasoning: Knowledge-Based Agents, The Wumpus World. | 10 Hours |
| Module-3 | Knowledge and Reasoning: Logic, Propositional Logic, Reasoning Patterns in Propositional Logic; First-Order Logic: Syntax and Semantics of First-Order Logic, Using First-Order Logic, Knowledge Engineering in First-Order Logic; Inference in First-Order Logic: Propositional vs. First-Order Logic, Unification and Lifting, Forward Chaining, Backward Chaining, Resolution; Knowledge Representation: Ontological Engineering , Categories and Objects, Semantic Nets, Frames. | 8 Hours |
| Module-4 | Planning: The Planning Problem, Planning with State-Space Search, Partial-Order Planning, Planning Graphs; Uncertain Knowledge & Reasoning: Acting under Uncertainty, Bayes Rule and its use; Probabilistic Reasoning: Representing Knowledge in an Uncertain Domain, Semantics of Bayesian Networks. | 8 Hours |
| Module-5 | Learning: Learning from Observations, Forms of Learning, Inductive Learning, Learning Decision Trees; Statistical Learning, Instance Based Learning, Neural Networks; Reinforcement Learning: Passive and Active Reinforcement Learning; Expert Systems: Introduction, Architecture, Representations. | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. S. Russell and P. Norvig, *Artificial Intelligence - A Modern Approach*, 3rd Edition, Pearson Education, 2016.
- T2. D. W. Patterson, *Introduction to Artificial Intelligence & Expert Systems*, 1st Edition, Pearson Education, 2015.

Reference Books:

- R1. E. Rich, K. Knight, and S. B. Nair, *Artificial Intelligence*, 3rd Edition, McGraw Hill Education, 2009.
- R2. G. F. Luger, *Artificial Intelligence: Structures and Strategies for Complex Problem Solving*, 6th Edition, Pearson Education, 2008.
- R3. M. Negnevitsky, *Artificial Intelligence: A Guide to Intelligent Systems*, 3rd Edition, Addison Wesley, 2.
- R4. N. J. Nilson, *Principles of Artificial Intelligence*, Narosa, 2002.
- R5. E. Charniak and D. McDermott, *Introduction to Artificial Intelligence*, 1st Edition, Addison-Wesley, 1985.

Online Resources:

1. <https://nptel.ac.in/courses/106/102/106102220/>: by Prof. Mausam, IIT Delhi
2. <https://nptel.ac.in/courses/112/103/112103280/>: by Prof. S. M. Hazarika, IIT Guwahati
3. <https://nptel.ac.in/courses/106/106/106106140/>: by Prof. D. Khemani, IIT Madras
4. <https://nptel.ac.in/courses/106/106/106106126/>: by Prof. D. Khemani, IIT Madras
5. <https://nptel.ac.in/courses/106/105/106105079/>: by Prof. P. Dasgupta, IIT Kharagpur

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

| | |
|-----|---|
| CO1 | Explore agents, environments, and search goal state using uninformed techniques in a state space. |
| CO2 | Apply search techniques for game playing and solving constraint satisfaction problems. |
| CO3 | Interpret logic, inference rules for decision making, and represent knowledge using semantic nets & frames. |
| CO4 | Apply planning and reasoning to handle uncertainty in real life problems. |
| CO5 | Use learning to solve complex real-life problems and design expert systems. |

Program Outcomes Relevant to the Course:

| | |
|-----|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO6 | 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. |

Cont'd...

| | |
|------|--|
| PO12 | 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. |
|------|--|

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Introduction to Machine Learning | L-T-P | Credits | Marks |
|------|---------------|----------------------------------|-------|---------|-------|
| OE | BTCS-T-OE-044 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|--|
| Objectives | The objective of this course is to study various supervised, unsupervised, and reinforcement learning techniques & algorithms to discover patterns in data and make predictions based on the patterns for solving business problems. |
| Pre-Requisites | Knowledge of engineering mathematics is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|--|-----------------|
| Module-1 | Overview of supervised learning, K-nearest neighbour, Multiple linear regression, Shrinkage methods (Ridge regression, Lasso regression), Subset selection, Linear Discriminant Analysis, Logistic regression. | 9 Hours |
| Module-2 | Bias, Variance, and model complexity, Cross-validation, Bootstrap methods, Regression and classification trees, Boosting methods, AdaBoost and Random forest. | 8 Hours |
| Module-3 | Generative model for discrete data (Bayesian concept learning, Naïve Bayes classifier), SVM for classification, Reproducing Kernels, SVM for regression. | 8 Hours |
| Module-4 | Clustering (K-means, spectral clustering), Feature Extraction (Principal Component Analysis (PCA), kernel based PCA, Independent Component Analysis (ICA), Non-negative matrix factorization). | 9 Hours |
| Module-5 | Introduction to Reinforcement learning, Single State Case: K-Armed Bandit, Elements of Reinforcement Learning, Model-Based Learning (Value Iteration, Policy Iteration). | 8 Hours |
| Total | | 42 Hours |

Text Books:

- T1. T. Hastie, R. Tibshirani, and J. Friedman, *The Elements of Statistical Learning - Data Mining, Inference, and Prediction*, 2nd Edition, Second Edition, 2009.
- T2. S. Haykin, *Neural Networks and Learning Machines*, 3rd Edition, Pearson Education, 2009.
- T3. E. Alpaydm, *Introduction to Machine Learning*, 2nd Edition, Prentice Hall of India, 2010.

Reference Books:

- R1. Y. G. James, D. Witten, T. Hastie, and R. Tibshirani, *An Introduction to Statistical Learning with Applications in R*, 2nd Edition, Springer, 2013.
- R2. T. M. Mitchell, *Machine Learning*, 1st Edition, McGraw-Hill Education, 2013.
- R3. C. M. Bishop, *Pattern Recognition and Machine Learning*, 1st Edition, Springer, 2006.

Online Resources:

1. <https://nptel.ac.in/courses/106/106/106106139/>: by Dr. B. Ravindran, IIT Madras
2. <https://nptel.ac.in/courses/106/105/106105152/>: by Prof. S. Sarkar, IIT Kharagpur

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

| | |
|-----|--|
| CO1 | Apply supervised machine learning models to solve related real life problems. |
| CO2 | Analyze and select the best suitable supervised models among many. |
| CO3 | Apply classification and regression models such as SVM and decision tree based models. |
| CO4 | Extract important features from the given data set and apply clustering techniques. |
| CO5 | Apply reinforcement learning models to solve related real life problems. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
| PO2 | Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | 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. |
| PO4 | 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. |
| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO12 | 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. |

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Industrial Instrumentation | L-T-P | Credits | Marks |
|------|---------------|----------------------------|-------|---------|-------|
| OE | BTEI-T-OE-022 | | 3-0-0 | 3 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of the course is to study the processes, characteristics, functionalities, instrument analysis, telemetry systems, and power plant instrumentation along with industrial hazards & safety considerations. |
| Pre-Requisites | Basic knowledge of Electronics, Electrical Engineering, Communication Engineering and Internet Technology is required. |
| Teaching Scheme | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on programming & applications. |

Evaluation Scheme

| Teacher's Assessment | | | Written Assessment | | Total |
|----------------------|------------------|---------------|--------------------|----------|-------|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Term | End-Term | |
| 05 | 05 | 05 | 25 | 60 | 100 |

Detailed Syllabus

| Module-# | Topics | Hours |
|-----------------|---|-----------------|
| Module-1 | Introduction: Functional Units, Classification, Performance Characteristics, Dynamic Calibration, Errors: An Overview, Statistical Error Analysis, Reliability and related topics; Transducers: Pressure Transducers, Electrical and vacuum type, Pirani gauge, Thermocouple gauge, Ionization gauge, Flow meter – Turbo-magnetic, Electromagnetic, Ultrasonic type, Level sensor – Electrical type (contact & non-contact). | 10 Hours |
| Module-2 | Instruments for Analysis: Introduction, Gas Analysers, Liquid Analysers, X-ray Methods, Chromatography – Gas and Liquid, Nuclear Magnetic resonance spectroscopy, Electron spin resonance spectroscopy, Mass spectroscopy, Sampling techniques. | 9 Hours |
| Module-3 | Telemetry: Introduction, Pneumatic Means, Electrical Means - voltage, position and synchro transmitters & receivers, Frequency Telemetry, Multiplexing, Modulation, Modulation of Digital Data, Types of Transmission Channels and characteristic, Briefing of a Telemetry System in Operation, Wireless I/O. | 8 Hours |
| Module-4 | Power Plant Instruments: Introduction, The Power Plant Scheme, Pressure, Temperature, Flow and Level, Vibration and Expansion, Analysis – Conductivity, Silica, Sodium, pH, DO, Turbidity and Hydrazine, Flue Gas Analysis. | 8 Hours |
| Module-5 | Hazards and Safety: Initial consideration, Enclosures – NEMA type, IP type, Intrinsic Safety, Prevention of Ignition, Methods of Production; Analysis, Evaluation and Construction – Intrinsically safe installation, Unbalanced and balanced schemes. | 7 Hours |
| Total | | 42 Hours |

Text Books:

- T1. D. Patranabis, *Principle of Industrial Instrumentation*, 3rd Edition, McGraw-Hill, 2012.
 T2. R. S. Khandpur, *Handbook of Analytical Instruments*, 3rd Edition, Tata McGraw-Hill, 2015.

Reference Books:

- R1. B. G. Liptak, *Process Measurement and Analysis*, 3rd Edition, Chilton Book Company, 1995.
- R2. J. P. Bentley, *Principles of Measurement Systems*, 4th Edition, Pearson Education, 2005.
- R3. A. K. Ghosh, *Introduction to Measurement and Instrumentation*, 3rd Edition, PHI Learning, 2009.
- R4. D. Patranabis, *Sensors and Transducers*, 2nd Edition, PHI Learning, 2010.
- R5. D. V. S Murthy, *Transducers and Instrumentation*, 4th Edition, PHI Learning, 2000.

Online Resources:

1. <https://nptel.ac.in/courses/108/105/10810506/>: by Dr.A. Barua, IIT Kharagpur
2. <https://nptel.ac.in/courses/108/105/108105062/>: by Prof. S. Mukhopadhyay and Prof. S. Sen, IIT Kharagpur
3. <https://nptel.ac.in/courses/108/105/108105088/>: by Prof. S. Mukhopadhyay, IIT Kharagpur

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

| | |
|-----|--|
| CO1 | Describe the characteristics of instruments and uses of transducers in industry. |
| CO2 | Identify the instruments for the analysis of chemical composition in industry. |
| CO3 | Explain the principles & working of telemetry systems and their industrial applications. |
| CO4 | Describe the various components of power plant instrumentation and its usage. |
| CO5 | Realize hazards in industry and practice safety principles in instrumentation. |

Program Outcomes Relevant to the Course:

| | |
|------|--|
| PO1 | Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. |
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| PO5 | Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | 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. |
| PO7 | 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. |
| PO8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| PO12 | 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. |

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

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

| Type | Code | Emerging Technologies Lab | L-T-P | Credits | Marks |
|------|---------------|---------------------------|-------|---------|-------|
| PC | BTEC-P-PC-023 | | 0-0-2 | 1 | 100 |

| | |
|------------------------|---|
| Objectives | The objective of this laboratory course is to provide practical exposure on latest & emerging tools & technologies of current demand in various electronics & communication engineering domains so as to make the students adapt to the fast-changing world of technology and make them ready for the industry. |
| Pre-Requisites | Knowledge of subjects taught in previous semesters is required. Additional topics (if any) required to perform the experiments shall be taught in the lab. |
| Teaching Scheme | Regular laboratory experiments to be conducted under the supervision of the teacher. Demonstration will be given for each experiment. |

Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test/ Mini Project | Viva-voce | Total |
|------------|-------------------|------------|---------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|---|---|
| <i>Any 12 (twelve) Experiments to be conducted as assigned by the teacher</i> | |
| 1 | To interface LED with ARM-7 and write program to flash LED. |
| 2 | To interface keys with ARM-7. |
| 3 | To interface seven segment display with ARM-7. |
| 4 | To interface LCD with ARM-7. |
| 5 | To interface relay with ARM-7. |
| 6 | To interface and control the speed of DC motor with ARM-7. |
| 7 | To interface stepper motor with ARM-7. |
| 8 | To interface ADC with ARM-7. |
| 9 | To interface ZIGBEE with ARM-7 to control more external device. |
| 10 | To interface RFID module with ARM-7. |
| 11 | Familiarization with Arduino/Raspberry Pi and perform necessary software installation. |
| 12 | To interface LED/Buzzer with Arduino/Raspberry Pi and write a program to turn ON LED for 1 sec after every 2 seconds. |
| 13 | To interface Push button/Digital sensor (IR/LDR) with Arduino/Raspberry Pi and write a program to turn ON LED when push button is pressed or at sensor detection. |
| 14 | To interface DHT11 sensor with Arduino/Raspberry Pi and write a program to print temperature and humidity readings. |
| 15 | To interface motor using relay with Arduino/Raspberry Pi and write a program to turn ON motor when push button is pressed. |
| 16 | To interface OLED with Arduino/Raspberry Pi and write a program to print temperature and humidity readings on it. |
| 17 | To interface Bluetooth with Arduino/Raspberry Pi and write a program to send sensor data to smartphone using Bluetooth. |

Cont'd...

| Experiment-# | Assignment/Experiment |
|--------------|---|
| 18 | To interface Bluetooth with Arduino/Raspberry Pi and write a program to turn LED ON/OFF when '1'/'0' is received from smartphone using Bluetooth. |
| 19 | Write a program on Arduino/Raspberry Pi to upload temperature and humidity data to thingspeak cloud. |
| 20 | Write a program on Arduino/Raspberry Pi to retrieve temperature and humidity data from thingspeak cloud. |
| 21 | To install MySQL database on Raspberry Pi and perform basic SQL queries. |
| 22 | Write a program on Arduino/Raspberry Pi to publish temperature data to MQTT broker. |
| 23 | Write a program on Arduino/Raspberry Pi to subscribe to MQTT broker for temperature data and print it. |
| 24 | Write a program to create TCP server on Arduino/Raspberry Pi and respond with humidity data to TCP client when requested. |
| 25 | Write a program to create UDP server on Arduino/Raspberry Pi and respond with humidity data to UDP client when requested. |

Text Books:

- T1. K. V. Shibu, *Introduction to Embedded Systems*, 2nd Edition, McGraw-Hill Education, 2017.
- T2. R. Kamal, *Embedded Systems : Architecture, Programming and Design*, 12th Reprint, Tata McGraw-Hill, 2007.
- T3. A. Bahga and V. Madiseti, *Internet of Things : A Hands-On Approach*, 1st Edition, Universities Press, 2014.
- T4. D. Hanes, G. Salgueiro, P. Grossetete, R. Barton, and J. Henry, *IoT Fundamentals : Networking Technologies, Protocols, and Use Cases for the Internet of Things*, 1st Edition, Pearson Education, 2017.

Reference Books:

- R1. D. E. Simon, *An Embedded Software Primer*, Addison Wesley, 1999.
- R2. D. Kellmerit and D. Obodovski, *The Silent Intelligence : The Internet of Things*, 1st Edition, Lightning Source Inc., 2014.
- R3. M. Schwartz, *Internet of Things with Arduino Cookbook*, Packt Publishing, 2016.

Online Resources:

1. <https://nptel.ac.in/courses/106105159/>: By Prof A. Basu, IIT Kharagpur
2. <https://nptel.ac.in/courses/106/105/106105195/>: By Prof. S. Misra, IIT Kharagpur.
3. <https://nptel.ac.in/courses/108/108/108108098/>: By Prof. T. V. Prabhakar, IISc Bangalore
4. <https://nptel.ac.in/courses/108/105/108105064/>: By Prof. A. Barua, IIT Kharagpur
5. <https://nptel.ac.in/courses/106/104/106104189/>: By Dr. R. Misra, IIT Patna

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

| | |
|-----|--|
| CO1 | Explain the pin diagram of the ARM 7 processor. |
| CO2 | Realize & conceive different applications using the ARM 7 processor. |
| CO3 | Develop expertise on designing systems with Arduino/Raspberry Pi. |
| CO4 | Use Arduino/Raspberry Pi for different practical applications. |

P.T.O

Program Outcomes Relevant to the Course:

| | |
|------|--|
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|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|
| CO1 | 1 | 2 | 3 | 3 | 3 | | | | | | | 2 | 2 | | 1 |
| CO2 | 3 | 3 | 2 | 3 | 3 | 1 | 1 | | | | | 2 | 3 | 1 | 2 |
| CO3 | 3 | 3 | 2 | 3 | 3 | | | | | | | 2 | 3 | | 1 |
| CO4 | 2 | 2 | 2 | 3 | 3 | 1 | | | | | | 2 | 2 | 1 | 2 |



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