Silicon Institute of Technology
| An Autonomous Institute |

Curriculum Structure and Detailed Syllabus

Bachelor of Technology in Electronics & Instrumentation Engineering

Silicon
...beyond teaching

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

Effective From Academic Year 2020-21

Version: 1.30 (Build: 30-08-2022)

Approval History

ACM#	Date	Resolutions
AC-4	18/08/2020	The curriculum structure and detailed syllabus of 1st Year as proposed by the Boards of Studies is approved by the Academic Council.
AC-6	09/10/2021	The curriculum structure and detailed syllabus of 2nd 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 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, formulate, and solve various complex engineering problems related to sensors, process instrumentation, VLSI, Biomedical and Real-time Embedded Systems by applying fundamental concepts of electronics and instrumentation.

PSO2. Imbibe the skills in modern technologies, tools & platforms to become a successful professional or entrepreneur, develop a passion for innovation & higher studies, and contribute as a responsible citizen with effective communication, strong moral values & professional ethics.

PSO3. Appreciate and adapt to emerging technologies in electronics and related domains to design and create efficient systems for process automation in the real world using appropriate sensors, instruments, tools, and platforms to meet the challenges of the future.

Program Educational Objectives (PEOs)

PEO1. *Fundamental Knowledge & Core Competence*: To apply the knowledge of science, mathematics and principles of electronics & instrumentation engineering essential for a successful professional and inculcate competent problem-solving ability.

PEO2. *Proficiency for the Real World*: To inculcate the skills required to analyze, formulate, design, develop, test and optimize efficient and cost-effective electronics and instrumentation systems useful in various real world scenarios.

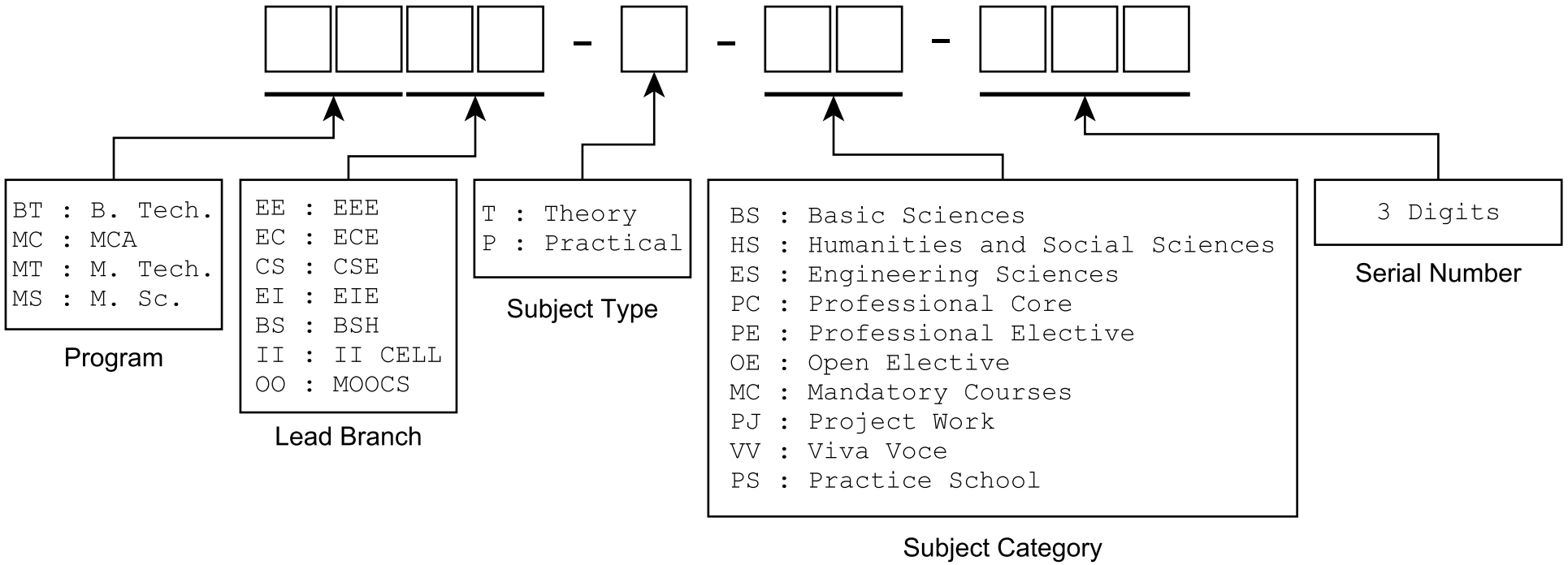
PEO3. *Leadership & Social Responsibility*: To exhibit leadership capability with professional, ethical, interpersonal skills, social & economic commitment with a sense of responsibility towards public policies, community services, humanity and environment.

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



Contents

Part I

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

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-012	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-010	Communicative & Technical English	3	0	0	3	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	**16**	**0**	**12**	**14**	**0**	**6**
		TOTAL	**28**			**20**		

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.	**8 Hours**
Module-2	First order ordinary differential equations and applications.	**7 Hours**
Module-3	Second order ordinary differential equations and applications to electrical circuits.	**12 Hours**
Module-4	Matrix algebra, system of linear equations, rank and inverse of matrices.	**8 Hours**
Module-5	Eigen values and Eigen vectors, complex matrices, diagonalization of matrices.	**7 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.

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 graphs of functions (curves) by knowing their characteristics like asymptotes and curvature.
CO2	Solve first order ordinary differential equations using various methods and apply them to physical problems.
CO3	Learn methodology to Solve second order ordinary differential equations and apply them to solve applied problems of electrical circuits.
CO4	Develop understanding of the concepts and methods of system of linear equations and apply them to solve a system.
CO5	Study and use the eigen values and eigen vectors of matrices, its properties and 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.

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:

1. https://chem.libretexts.org/Core/Analytical_Chemistry/Electrochemistry/Exemplars/Corrosion/Corrosion_Basics
2. https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/spectrpy/infrared/infrared.htm
3. http://nptel.ac.in/courses/103105110/ - Fuel & Combustion
4. http://nptel.ac.in/courses/105104102/hardness.htm
5. http://nptel.ac.in/courses/105106112/1_introduction/5_corrosion.pdf
6. 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					1	1	
CO2	3	2	1	1	1	2	1						1	1	
CO3	2	2	1	1	2	2	1	1					2	1	
CO4	2	2	1	1	1	1	1						2	1	
CO5	2	2	1	1	2	2	1	1					2	1	

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:

1. https://ocw.mit.edu/courses/physics/8-04-quantum-physics-i-spring-2013/
2. http://www.ilectureonline.com/lectures/subject/PHYSICS
3. https://ocw.mit.edu/courses/physics
4. https://nptel.ac.in/courses/115102026/
5. 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	3	3
CO2	3	2	1	2	1							1	3	2	1
CO3	3	2		1								1	3	2	1
CO4	3	2		1								1	3	2	1
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 Rohit 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	1
CO2	3	2	3	1									2	2	2
CO3	2	2	2	1									3	3	2
CO4	3		3										2	2	1
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. Kanetker, ***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	Communicative & Technical English	L-T-P	Credits	Marks
HS	BTBS-T-HS-010		3-0-0	3	100

Objectives	The objectives of this course are to develop the students' communication skills with proficiency in Technical English, to make them aware of the importance of cross-cultural communication, to develop analytical skills to read and comprehend texts, and to help compose effective 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 Technical Communication**: General vs Technical Communication; Factors, participants, code, channels, message, feedback, Effective Business Communication; Importance of technical communication; Communication across cultures and common problems; Barriers to effective communication.	**6 Hours**
Module-2	**Sounds of English**: vowels, diphthongs, consonants and consonant clusters, problem sounds, phonemic transcription, syllabic division and stress, weak forms and rhythm, intonation.	**5 Hours**
Module-3	**Effective Business Communication**: Structure of a business organization; purpose of business organization; Technology in communication; use of bias-free language; channels of communication: upward, downward, diagonal, grapevine, open door communication; forms of technical communication: internal, external, formal, informal, oral, written. Language structures for day-to-day business communication: persuasion, negotiation, argumentation, making suggestions, assertive communication. Public speaking and presentation skills; content development; clarity of speech; emotions displayed by body language, personal space and zones, personal appearance and attitude to time.	**9 Hours**
Module-4	**Critical Reading**: sub-skills of reading; reading a feature article; reading an editorial; skimming through a short report; reading contemporary essays; reading prescribed English short stories.	**11 Hours**
Module-5	**Effective Business Writing**: constituents of effective writing: ; paragraph development: coherence, cohesion, progression of ideas, elements of style, clarity and precision, avoiding redundancy, circumlocution, jargons; Dealing with positive and negative messages; business writing: writing a memo; writing an e-mail, writing business letters, notice, writing different types of reports, writing a proposal.	**11 Hours**
	Total	**42 Hours**

Text Books:

T1. M. A. Rizvi, ***Effective Technical Communication***, McGraw Hill.
T2. T. Balasubramaniam, ***English Phonetics for Indian Student***, Trinity Press.
T3. B. K. Das, ***An Introduction to Professional English and Soft Skills***, Cambridge Univ. Press, 2009.
T4. D. K. Das, A. Kumari, K. K. Padhi, ***Anthology of Modern English Prose***, Triniti 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 Univ. Press.
R3. B. K. Mitra, ***Communication Skills for Engineers***, Oxford Univ. Press, 2011.
R4. M. Raman, S. Sharma, ***Technical Communication: Principles & Practice***, Oxford Univ. Press.

Online Resources:

1. http://www.cambridgeindia.org
2. http://www.cambridgeenglish.org/exams/business-certificates/business
3. https://steptest.in
4. https://www.coursera.org/specializations/business-english
5. http://www.academiccourses.com/Courses/English/Business-English

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

CO1	Understand the elements of technical communication and communication across cultures.
CO2	Learn about aspects of English pronunciation and speak using a neutral accent.
CO3	Learn about the channels of business communication and business hierarchies in order to communicate effectively in a business set up.
CO4	Enhance their reading skills and be able to critically analyse texts of various kind.
CO5	Compose different types of 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	2	3	2	3	1	3	1
CO2									1	3	1	3	1	2	1
CO3								1	3	3	2	3		3	1
CO4										3		3	1	3	1
CO5								2	1	3	1	3		3	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.

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 Assesment (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	2	1
CO2	1					2	2	2	2		1		1	2	1
CO3	1					1	2	1	1		1		1	2	2
CO4	1					2	3	1	2		1		1	2	1
CO5	1					3	3	3	2		1			2	1

Type	Code	Engineering Mathematics - II	L-T-P	Credits	Marks
BS	BTBS-T-BS-012		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	Laplace transform, Inverse Laplace transform, shifting theorems, Transform of derivatives and integrals, Unit step function and Dirac delta function, applications to differential equations.	**7 Hours**
Module-2	Differentiation & Integration of Transforms, Convolution and integral equations, Use of partial fraction, system of differential equations.	**7 Hours**
Module-3	Random Experiment & Probability, Conditional Probability, Bayes' Rule, Random variable & Probability Distribution, Mean, Variance.	**8 Hours**
Module-4	Uniform Discrete Distributions: Binomial, Poisson, Geometric Random Variable, Continuous Uniform Distribution: Normal Distribution, Exponential Distribution.	**8 Hours**
Module-5	Joint Distribution, Covariance, Sampling & sampling distributions, maximum likelihood estimation, Estimation of mean, Confidence Interval of mean, variance.	**7 Hours**
Module-6	Testing of Hypothesis about mean, variance, Testing goodness of fit, Linear regression, least square line, correlation coefficient.	**5 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, MC Graw Hill, 2017.

Online Resources:

1. http://www.nptel.ac.in/courses/111105035/32
2. http://www.nptel.ac.in/courses/122104017
3. http://nptel.ac.in/courses/122102009
4. www.edx.org/Probability
5. https://ocw.mit.edu/courses/.../18-440-probability-and-random-variables-spring-2014/

6. https://ocw.mit.edu/courses/mathematics/18-03sc-differential-equations-fall-2011/unit-iii-fourier-series-and-laplace-transform/laplace-transform-basics/

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

CO1	Study and use the concepts of probability and random variables and applying them to evaluate probabilities of different events.
CO2	Know different discrete and Continuous probability models and apply those to solve probability problems of day to day activities.
CO3	Understand the applications of joint & sampling distributions.
CO4	Learn methodology to apply statistical testing and regression.
CO5	Study the concepts of Laplace Transform and to apply those for solving ODE.
CO6	Develop understanding of convolution and its application to integral 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	2	2	2								3	2	1
CO2	3	3	3	3	3								3	2	1
CO3	3	2	3	2	2								2	1	1
CO4	3	3	3	3	2								2	1	1
CO5	3	3	2	2	3								2	1	1
CO6	3	3	2	2	3								2	1	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	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
	At least 10 Experiments
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-Martein's 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 the demonstrate of 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:

1. https://www.metrohm.com/en/industries/petro-lubricants/: Lubricant analysis according to international standards
2. 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 viscocity 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	
CO2	2	2		1	2		2		2	2			1	1	
CO3	3	2		1	2		1		2	2			1	1	
CO4	3	3		1	1		2		2	2			1	1	
CO5	3	2		1	1		1		1	1			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	2	2	1
CO3	2	1		2									3	2	2
CO4	2	2		3	1								3	2	2
CO5	3	1		1								1	2	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 of fitting practice and tools used in fitting jobs.
2	Exercise involving measuring, marking, cutting and filing practice.
3	Fitting of male and female mating parts.
4	Introduction of Lathe, exercise involving facing, straight turning, step turning, taper turning and thread cutting in Lathe machine.
5	Introduction of Milling and Shaping machines.
6	Preparing single step on a square block in Milling machine.
7	Preparing a key way on a square block in Shaping machine.
8	Introduction to basic principles of Arc and Gas welding.
9	Preparing lap joint by Gas welding and butt joint by Arc welding.
10	Sheet metal forming and joining operations.

Text Books:

T1. P. Kannaiah and K. L. Narayana, ***Workshop Manual***, Sceitech Publishers, 2009.
T2. S. K. Hajra Choudhury, ***Elements of Workshop Technology***, Vol-1 and Vol-2, MPP..

Reference Books: *There are no reference books for this subject.*

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)

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

CO1	Study and practice use of hand tools and their operations in a fitting shop.
CO2	Design and model various basic prototypes in fitting, such as a Paper weight.
CO3	Design and model and use of various suitable tools form a chining processes like facing, straight turning, step turning, taper turning and thread cutting.

Cont'd...

CO4	Identify and use suitable tools for cutting of a mild steel work piece with the help of shaping and milling machines.
CO5	Design and model various basic prototypes in welding such as a Lap joint and Butt joint.
CO6	Design and model various basic prototypes using sheet metal forming and joining operations.

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.
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.
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			1			3		3	2		1	1
CO2	1		2			1			3		3	2		1	1
CO3	1		2			1			3		3	2		1	1
CO4	1		2			1			3		3	2		1	1
CO5	1		2			1			3		3	2		1	1
CO6	1		2			1			3		3	2		1	1

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

Objectives	To create awareness and emphasize the need for Engineering Graphics in all the branches of engineering, to follow basic drawing standards and conventions, to develop skills in three-dimensional visualization of engineering component, to solve specific geometrical problems in plane geometry involving lines, plane figures and special curves, to produce orthographic projection of engineering components working from pictorial drawings.
Pre-Requisites	Basic understanding of Geometry
Teaching Scheme	Regular laboratory classes using drawing tools under supervision of the teacher. Demonstration will be given for each drawing assignment using ICT as when required.

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, usage of various drawing instruments, lettering, dimensioning principles.
2	Conics and Engineering Curves.
3	Orthographic Projections: Principles of orthographic projections - conventions, projections of points and lines.
4	Auxiliary projection Technique: Projection of Points and lines on Auxiliary Planes.
5	Projections of Planes: projections of planes in simple position & inclined to both planes.
6	Projection of Solids: projection of solids in simple position & inclined to both planes.
7	Principles of Isometric projection, isometric scale, isometric views, conventions, isometric views of lines & planes.
8	Isometric projections of solids, conversion of isometric views to orthographic views.
9	Development of surface and intersection of surfaces.
10	Sections and sectional views of simple and compound solids.
11	Introduction to AUTOCAD tools.

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. R. K. Dhawan, ***A Text Book of Engineering Drawing***, S. Chand Publications, 2007.
T4. K. L. Narayana, P. Kannaiah, ***Text Book on Engineering Drawing***, Scitech Publishers, 2008.

P.T.O

Reference Books:

R1. T. E. French, C. J. Vierck, R. J. Foster, ***Graphic Science and Design***, 4th Edition, McGraw-Hill.
R2. W. J. Luzadder, J. M. Duff, ***Fundamentals of Engineering Drawing***, 11th Edition, PHI, 1995.
R3. K. Venugopal, ***Engineering Drawing and Graphics***, 3rd Edition, New Age International, 1998.

Online Resources:

1. http://nptel.ac.in/courses/112103019
2. https://freevideolectures.com/course/3420/engineering-drawing
3. http://www.engineeringdrawing.org/
4. https://ocw.mit.edu/courses/mechanical-engineering/2-007-design-and-manufacturing-i-spring-2009/related-resources/drawing_and_sketching/

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 Engineering Curves.
CO2	Recognize and be familiar with the Orthographic projections of points, lines.
CO3	Develop the concept of Orthographic projections of planes and solids.
CO4	Differentiate between isometric scale, isometric projections and views.
CO5	Have a broad overview of various sheet-metal work by the concept of development of surfaces and solids and Sectional Views of Simple and compound solids.
CO6	Draw various machine components and building structure drawing 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.

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	1
CO2	3	3	2	1									2	2	2
CO3	2	2	2	1									3	2	2
CO4	2	2	3										3	2	1

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. Kanetker, ***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	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	Ice-breaking activities: dealing with inhibitions to speak (team activity)
2	Just a Minute (individual activity)
3	Role Play on channels of communication in the business world (team activity)
4	Speech activity 1: content development (individual activity)
5	Speech activity 2: for fluency, delivery and appropriate body language (individual activity)
6	Ear training: developing pronunciation skills (individual activity)
7	Listening comprehension: listening for overall and specific information (individual activity)
8	Oral presentations: preparing for public speeches (team activity)
9	Reading comprehension 1 (individual activity)
10	Reading comprehension 2 (individual activity)
11	Group presentation (team activity)
12	Writing Activity 1 (individual activity)
13	Writing Activity 2 (individual activity)

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	Communicate in simulated business contexts.
CO3	Develop English pronunciation skills through practice.
CO4	Work effectively as a member of a team or as a leader through group presentation assignments.
CO5	Critically analyse texts of various kind 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								1	1	3	1	3	1	2	1
CO2								1	3	3	2	3	1	2	1
CO3										3		3	1	2	1
CO4								2	3	3	2	3	1	3	2
CO5								1	1	3		3	1	2	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

Part II

2nd Year B. Tech. (EIE)

Curriculum Structure

Semester III									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
BS	BTBS-T-BS-040	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	BTEI-T-PC-999	Basics of Instrumentation	3	0	0	3	0	0
PC	BTEE-T-PC-003	Circuit Theory	3	0	0	3	0	0
PC	BTEI-T-PC-001	Analog Electronic Circuits	3	0	0	3	0	0
PRACTICAL									
ES	BTCS-P-ES-006	OOP Using Java Lab	0	0	2	0	0	1
PC	BTEI-P-PC-999	Basics of Instrumentation Lab	0	0	2	0	0	1
PC	BTEE-P-PC-004	Circuit Theory Lab	0	0	2	0	0	1
PC	BTEI-P-PC-002	Analog Electronic Circuits Lab	0	0	2	0	0	1
MC	BTBS-P-MC-017	Yoga	0	0	2	0	0	0
PJ	BTII-P-PJ-001	Summer Internship - I	0	0	0	0	0	1
		SUB-TOTAL	**15**	**0**	**10**	**15**	**0**	**5**
		TOTAL	**25**			**20**		

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-010	Digital Electronic Circuits	3	0	0	3	0	0
PC	BTEI-T-PC-003	Transducers & Measurement Systems	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
PRACTICAL									
PC	BTEC-P-PC-011	Digital Electronic Circuits Lab	0	0	2	0	0	1
PC	BTEI-P-PC-004	Transducers & Measurement Systems Lab	0	0	2	0	0	1
PC	BTEE-P-PC-006	Control Systems Engineering Lab	0	0	2	0	0	1
		SUB-TOTAL	**18**	**1**	**6**	**18**	**1**	**3**
		TOTAL	**25**			**22**		

Note: *Courses offered under each elective are given in "List of Electives" on Page 52.*

List of Electives

Code	Elective # and Subjects
	Open Elective - 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
BTEC-T-OE-099	[ECE] Information Theory & Coding
BTCS-T-OE-040	[CSE] Fundamentals of DBMS

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-040		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 other special functions important 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, Fourier cosine transform, Fourier since transform, Fourier transform.	**10 Hours**
Module-5	Power series solutions to ordinary differential equations, Legendre Equation, Bessel's function and its properties, Gamma function, Beta function, Error function.	**8 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 function.
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 transforms of functions.
CO5	Understand the concepts of power series solution and some important special functions.

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, LinkList, 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	Basics of Instrumentation	L-T-P	Credits	Marks
PC	BTEI-T-PC-999		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: Static & dynamic characteristics, standards of measurement, input and output impedance, loading effects of series and shunt connected instruments; Errors in Measurement: types of error, normal distribution of errors and concept of calibration and curve fitting, linear & weighted regression.	**8 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, Mega Ohm, Inductance measurement (Maxwell's, Hay's, and Anderson bridge) and Capacitance measurement (Wien's, Owens's and Schering Bridge), Shielding & grounding.	**9 Hours**
Module-3	Measuring Instruments: DC galvanometer, PMMC and Moving Iron instruments, DC Potentiometer, voltmeters, ammeters, ohmmeters and extension of range of instruments, AC indicating instruments: EDM type instruments, EDM Wattmeter (single-phase & three-phase) and errors present, Energy meter; Basics of instrument transformer, Digital CRO, Digital voltmeter, Digital counter, Digital frequency meter, and Spectrum Analyzer.	**9 Hours**
Module-4	Primary Sensing Elements: Sensors, Transducers and its classification & selection of transducers; Basic sensing elements for displacement, temperature, velocity, speed, vibration, acceleration, force, torque and pressure measurement; Liquid and solid level & flow measurement, IC based sensor, Push-pull type Capacitive, Oscillator based measurements, Hall effect based sensors.	**9 Hours**
Module-5	Basic concepts of smart sensors and applications; Signal conditioning, Modulation and Demodulation Techniques, basic of telemetry system and data acquisition systems.	**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. A. D. Helfrick and W. D. Cooper, ***Modern Electronic Instrumentation and Measurement Techniques***, 1st Edition, Pearson Education, 2015.
R4. J. B. Gupta, ***A Course in Electrical and Electronic Measurements & Instrumentation***, 1st Edition, S. K. Kataria & Sons, 2013.
R5. 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, 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 smart sensors 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.

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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.
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	2	2	1		1							3	2	3
CO2	3	3	1	2			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	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 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, Tellegen's theorem, Millman's theorem, Compensation theorem (AC & DC Networks); 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.	**10 Hours**
Module-2	Fundamentals of Laplace & Inverse Laplace Transform, initial and final value theorem; Fundamentals of Switching behaviour of RL, RC & RLC circuits. Application Of Laplace Transform to Transient Analysis: Response of RL, RC & RLC network with step, sinusoidal, impulse and ramp input.	**10 Hours**
Module-3	Representation of Signals (Continuous Time), Fundamentals of Fourier Transform and Fourier series, Fourier Series Analysis of CT signals, Fourier Transform Analysis of CT Signals, Circuit analysis with Fourier Series, Circuit analysis with Fourier Transform.	**8 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	**44 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. 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	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.

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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	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	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)***, 6th Edition, Oxford University Press, 2013.
T2. R. L. Boylestad and L. Nashelsky, ***Electronic Devices and Circuit Theory***, 10th Edition, Pearson Education, 2009.
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	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 handing 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 robus 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	Basics of Instrumentation Lab	L-T-P	Credits	Marks
PC	BTEI-P-PC-999		0-0-2	1	100

Objectives	The objective of this laboratory course is to practically understand the concepts of static characteristics, dynamic characteristics, error analysis tools, principles, testing & calibration of different measuring instruments.
Pre-Requisites	Basic knowledge of different electrical and magnetic circuits. Topics taught in Basics of Instrumentation 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 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 static and dynamic characteristics of a Measuring Instrument.
2	Statistical analysis of errors in measurement.
3	Measurement of Low Resistance using Kelvin's Double Bridge.
4	Measurement of Self Inductance using Anderson's Bridge.
5	Calibration of capacitance sensor using Schering Bridge.
6	Measurement of frequency using Wien's Bridge.
7	Measurement of R, L, and C using Q-meter (bandwidth of a resonance circuit and Q-meter).
8	Study and testing of energy meter and clamp meter.
9	Study of Lissajous pattern and measurement of unknown frequency.
10	Study the response of vibration sensor.
11	Measurement of force using strain gauge.
12	Displacement measurement using LVDT.
13	Level measurement using capacitive transducer & its calibration.
14	Time duration measurement using DAQ system and LabView.

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.

Reference Books:

R1. D. A. Bell, ***Electronic Instrumentation and Measurements***, 3rd Edition, Oxford University Press, 2013.
R2. A. D. Helfrick and W. D. Cooper, ***Modern Electronic Instrumentation and Measurement Techniques***, 1st Edition, Pearson Education, 2015.
R3. J. B. Gupta, ***A Course in Electrical and Electronic Measurements & Instrumentation***, 1st Edition, S. K. Kataria & Sons, 2013.
R4. D. V. S. Murthy, ***Transducers and Instrumentation***, 2nd Edition, PHI Learning, 2008.

R5. A. K. Sawhney, ***A Course in Electrical and Electronics Measurements & Instrumentation***, Dhanpat Rai & Co, 2015.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105153/: by Prof. A. Chatterjee
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	Investigate performance characteristics and evaluate errors of a measuring instrument.
CO2	Accurately measure various electrical parameters using appropriate instruments.
CO3	Measure physical parameters using relevant sensors and measuring instruments.
CO4	Perform analysis on time domain signals to measure unknown parameters.
CO5	Investigate the response of measuring 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.
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	2	3							3	3	1	1
CO2	3	3	3	3	3							2	3	1	2
CO3	3	2	2	1	1							3	3	3	2
CO4	3	2	1	2	1							2	3	1	1
CO5	3	2	1	2	3							2	3	2	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	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	Yoga	L-T-P	Credits	Marks
MC	BTBS-P-MC-017		0-0-2	0	100

Objectives	To impart skills in students for control of mind, body and soul, enhance self-awareness, focus, and concentration, bring together physical and mental wellness, manage stress and anxiety, achieve perfect equilibrium and harmony of body & mind, and promote self-healing.
Pre-Requisites	There are no pre-requisites for this course.
Teaching Scheme	Regular practice classes conducted under supervision of the qualified Yoga teacher with necessary explanation and demonstration for each 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	Introduction to Yoga: Unison with the elements
2	*Prãnãyãma*: performing breathing exercise
3	*Mudrã*: learning various types of *Mudrã*s and their benefits
4	*Bandha*: learning various types of *Bandha*s and their benefits
5	*Chakra*: learning various types of *Chakra*s and their benefits
6	*Chakshu Visrãnt Ãsana Samuha*; eye movement and exercises
7	Twisting set: standing twisting *ãsana*
8	Side stretching set: standing Side stretching *ãsana*
9	Forward bending set: standing Forward bending *ãsana*
10	Backward bending set: standing Backward bending *aãsana*
11	Balancing set: learning *Vrikshãsana*, *Ekpada Pranamãsana* and benefits
12	*Surya Namaskãr*: surya namaskãr mantra and poses
13	*Vajrãsana* set: sitting *ãsana* sets
14	*Padmãsana* set: sitting *ãsana* sets
15	Sleeping ãsana and *Yoga Nidrã*: relaxation postures

Text Books:

T1. E. F. Bryant, ***The Yoga Sutras of Patanjali***, 1st Edition, North Point Press, 2009.

Reference Books:

R1. Swami Satyananda Saraswati, ***Asana Pranayama Mudra Bandha***, 4th Edition, Yoga Publication Trust, Munger (Bihar), India, 2008.

Online Resources: *There are a number of online resources available for this course. The student is advised to search on the Internet and locate the required study materials as per advise of the teacher.*

P.T.O

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

CO1	Promote positive health, get relief from stress and obtain balance of body & mind.
CO2	Acquire knowledge of integral approach of Yoga Therapy to common ailments.
CO3	Develop skills to adopt Yoga practices for health and general well-being.
CO4	Develop overall personality through control of body, mind and soul.
CO5	Enhance scientific attitude and team spirit for creative and constructive endeavors.

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.
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			2		1	2
CO2						1			1			2		1	2
CO3						2			1			2		1	2
CO4								2	3			1		2	3
CO5						2		2	2			1		2	3

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. Bhatacharya, 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 theormodynamics of pure substances.
CO4	Explain the design and operation of various devices based on theormodynamic 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
CO4	1	2	3	1	1									1	1
CO5	3	1	2	2	1									2	2

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 IC Gates; 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 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	Transducers & Measurement Systems	L-T-P	Credits	Marks
PC	BTEI-T-PC-003		3-0-0	3	100

Objectives	The objective of this course is to study the characteristics of different types of measurement systems and industrial applications of various transducers & sensors for design & construction of precise measuring instruments.
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 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**: Significance of measurement, functional elements of generalized measurement systems, deflection & null type instruments, analog/digital mode of operation, classification of transducers; Static Characteristics: Systematic and statistical characteristics, calibration; Dynamic Characteristics: Transfer functions of typical sensing elements, step & frequency response of first & second order elements, dynamic errors, dynamic compensation, loading effect, introduction to signal & noise.	**10 Hours**
Module-2	**Resistive Transducer**: Resistive potentiometers, strain gauges; Inductive Transducers: Variable reluctance displacement sensor, LVDT, RVDT, Hall effect sensors; Capacitive Transducers: Variable separation, area & dielectric displacement transducer, pressure, humidity and level measurement; Translational and Rotational Velocity Measurement: Moving coil moving magnet pickups, Eddy current magnetic & photoelectric pulse counting; Seismic Measurement: Seismic displacement, velocity & acceleration pickups.	**10 Hours**
Module-3	**Temperature Measurement**: Thermal expansion methods - Bimetallic, Liquid in glass, Thermocouples (Laws, Characteristics, Installation), RTDs (3-wire & 4-wire type), Thermistors, IC temperature sensors, Radiation detectors, Radiation pyrometer (narrowband & broadband), Optical pyrometer.	**9 Hours**
Module-4	**Force Measurement**: Bourdon tube, bellows, diaphragm, load cell; Torque Measurement: Torsion bar; Pressure Measurement: Units of pressure, dead weight gauges, Manometers, Mc-Leod gauge, Thermal conductivity and Ionization gauges; Flow Measurement: Variable Head (Orifice, Venturi, Pitot static), Variable area (Rotameters), Turbine meters, Electromagnetic flow meters, Ultrasonic flow meters, Doppler velocity meters, Hot wire anemometer and mass flow meter; Miscellaneous Sensors: Optical sensors, Principle, intensity and phase modulated sensors, FBG sensor.	**7 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	**Signal Conditioning System**: DC Bridge - Wheatstone Bridge, Calibration of the bridge, AC bridges, Linearization by Bridge circuit, Cold junction compensation of Thermocouple, Modulation and Demodulation Techniques, Signal Conditioning System, Signal Transmission.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. A. K. Ghosh, ***Introduction to Measurement and Instrumentation***, 3rd Edition, PHI Learning, 2009.
T2. J. P. Bentley, ***Principles of Measurement Systems***, 4th Edition, PHI Learning, 2005.
T3. C. D. Johnson, ***Process Control Instrumentation Technology***, 8th Edition, PHI Learning, 2014.

Reference Books:

R1. D. Patranabis, ***Sensors and Transducers***, 2nd Edition, PHI Learning, 2013.
R2. D. V. S. Murthy, ***Transducers and Instrumentation***, 2nd Edition, PHI Learning, 2008.
R3. E. O. Doeblin, ***Measurement Systems - Applications and Design***, 6th Edition, McGraw Hill, 2007.
R4. C. Rangan, G. Sarma, and V. S. V. Mani, ***Instrumentation : Devices and Systems***, 2nd Edition, McGraw Hill, 2017.
R5. B. G. Liptak, ***Instrument Engineers' Hand Book (Process Measurement & Analysis)***, 4th Edition, CRC Press, 2006.
R6. A. K. Sawhney, ***A Course in Electrical and Electronics Measurements & Instrumentation***, Dhanpat Rai & Co, 2015.

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. Mukhopadhyay and Prof. S. Sen, IIT Kharagpur
3. https://nptel.ac.in/courses/108/105/108105064/: by Prof. A. Barua, IIT Kharagpur
4. https://nptel.ac.in/courses/108/108/108108147/: By Prof. H. J. Pandya, IISc Bangalore

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

CO1	Describe the principles and characteristics of measuring instruments.
CO2	Explain the use of resistance, inductance and capacitance principles in transducers.
CO3	Identify and utilize various temperature sensors used in industrial applications.
CO4	Articulate the principles and uses of different force, torque, pressure sensors and flow meters.
CO5	Analyze the design of signal conditioning circuits and evaluate their performance.

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.

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								3	2	1
CO2	2	3	2	2	1								3	3	2
CO3	2	1	2	1	1								3	2	2
CO4	2	3	2	3	3								3	2	3
CO5	2	2	2	1	3								3	2	2

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:

1. https://nptel.ac.in/courses/108102043/
2. https://nptel.ac.in/courses/108106098/
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	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:

1. https://nptel.ac.in/courses/108/104/108104052/: by Dr. S. N. Singh, IIT Kanpur
2. 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 & irrational, 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	Information Theory & Coding	L-T-P	Credits	Marks
OE	BTEC-T-OE-099		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***, 2nd Edition, Tata McGraw-Hill, 2008.
T2. N. Abramson, ***Information and Coding***, McGraw-Hill Education, 1963.
T3. S. Haykin, ***Communication Systems***, 4th Edition, Wiley India, 2006.

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/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	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	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***, 5th Edition, Pearson Education, 2013.

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	Transducers & Measurement Systems Lab	L-T-P	Credits	Marks
PC	BTEI-P-PC-004		0-0-2	1	100

Objectives	The objective of this laboratory course is to get practical exposure to transducers and measurement systems for accurately measuring temperature, weight, position/displacement, pressure, flow, level, etc.
Pre-Requisites	Basic knowledge of physics, mathematics, electrical and electronics is required. Topics taught in TMS 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 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 the characteristics of RTD and Thermistor.
2	Temperature sensing using semiconductor type temperature sensor.
3	Weight measurement using strain gauge Load cell.
4	LVDT and its signal conditioning for position/displacement measurement.
5	Pressure measurement using Bourdon tube and diaphragm type sensor.
6	Temperature measurement using thermocouple.
7	Flow measurement using turbine type flow sensor.
8	Level measurement using capacitive transducers.
9	Speed measurement using optical and variable reluctance type transducers.
10	Design of active 2nd order low pass filter.
11	Calibration of capacitive level sensor.
12	Design of Instrumentation amplifier.
13	Design of Phase sensitive detector.
14	Study of the characteristics of Fiber Bragg Grating (FBG) sensor.

Text Books:

T1. J. P. Bentley, ***Principles of Measurement Systems***, 4th Edition, PHI Learning, 2005.
T2. A. K. Ghosh, ***Introduction to Measurement and Instrumentation***, 3rd Edition, PHI Learning, 2009.

Reference Books:

R1. D. Patranabis, ***Sensors and Transducers***, 2nd Edition, PHI Learning, 2013.
R2. D. V. S. Murthy, ***Transducers and Instrumentation***, 2nd Edition, PHI Learning, 2008.
R3. E. O. Doeblin, ***Measurement Systems - Applications and Design***, 6th Edition, McGraw Hill, 2007.

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. Mukhopadhyay and Prof. S. Sen, IIT Kharagpur

3. https://nptel.ac.in/courses/108/105/108105064/: by Prof. A. Barua, IIT Kharagpur
4. https://nptel.ac.in/courses/108/108/108108147/: By Prof. H. J. Pandya, IISc Bangalore

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

CO1	Analyze the characteristics of RTD and Thermistor.
CO2	Measure temperature, weight and position using different sensors.
CO3	Explain the techniques to measure flow, level and speed using various types of sensors.
CO4	Conceptualize and design different types of active filters.
CO5	Design instrumentation amplifiers and phase sensitive detectors.

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.
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	2	1	2		1		1			1	3	3	2
CO2	2	2	1	1	1		1		1			1	3	2	2
CO3	2	2	1	1	2		1		1			1	3	2	2
CO4	1	1	1	1	2				1				3	1	1
CO5	2	1	1	1	2				1				3	2	3

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

Part III

3rd Year B. Tech. (EIE)

Curriculum Structure

Semester V								
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
PC	BTEC-T-PC-037	Fundamentals of Microprocessor & Microcontrollers	3	0	0	3	0	0
PC	BTEI-T-PC-005	Instrumentation Devices & Systems	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
MC	BTBS-T-MC-020	Universal Human Values & Professional Ethics	2	0	0	0	0	0
PRACTICAL								
HS	BTBS-P-HS-021	Soft Skills & Inter-Personal Skills Lab	0	0	4	0	0	2
PC	BTEC-P-PC-038	Fundamentals of Microprocessor & Microcontrollers Lab	0	0	2	0	0	1
PC	BTEI-P-PC-006	Instrumentation Devices & Systems Lab	0	0	2	0	0	1
PJ	BTII-P-PJ-002	Summer Internship - II	0	0	0	0	0	1
		SUB-TOTAL	**17**	**0**	**8**	**15**	**0**	**5**
		TOTAL	**25**			**20**		

Semester VI								
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	BTEI-T-PC-022	Digital VLSI Design	3	1	0	3	1	0
PC	BTEC-T-PC-035	Introduction to Digital Signal Processing	3	0	0	3	0	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	BTEI-P-PC-022	Digital VLSI Design Lab	0	0	2	0	0	1
PC	BTEC-P-PC-036	Introduction to Digital Signal Processing Lab	0	0	2	0	0	1
PJ	BTEI-P-PJ-010	Skill Lab & Project - I	0	0	4	0	0	2
		SUB-TOTAL	**18**	**1**	**8**	**18**	**1**	**4**
		TOTAL	**27**			**23**		

Note: *Courses offered under each elective are given in "List of Electives" on Page 111.*

List of Electives

Code	Elective # and Subjects
Professional Elective - I	
BTEI-T-PE-043	IoT & Applications
BTEE-T-PE-051	Optoelectronic Devices & Instrumentation
BTEE-T-PE-038	Energy Conversion Devices
BTCS-T-PE-019	Computer Organization & Architecture
BTEI-T-PE-008	System Design Using Verilog
Professional Elective - II	
BTEI-T-PE-009	Advanced Sensor Technology
BTEE-T-PE-018	Power Electronics
BTEI-T-PE-013	Analog VLSI Design
BTEI-T-PE-052	PLC, Distributed Control System & SCADA
Professional Elective - III	
BTEI-T-PE-016	Bio-Medical Electronics
BTEE-T-PE-036	Soft Computing Techniques
BTEI-T-PE-017	Virtual Instrumentation
Open Elective - II	
BTEE-T-OE-033	[EEE] Power Station Engineering
BTBS-T-OE-029	[BSH] Numerical Optimization
BTBS-T-OE-030	[BSH] Organisational Behaviour
BTEC-T-OE-999	[ECE] Digital Communication
BTCS-T-OE-036	[CSE] Operating Systems
BTCS-T-OE-039	[CSE] Programming in Python
Open Elective - III	
BTEE-T-OE-034	[EEE] Renewable Energy Systems
BTBS-T-OE-031	[BSH] Stochastic Processes
BTBS-T-OE-032	[BSH] Project Management
BTEC-T-OE-061	[ECE] Advanced Communication Systems
BTEC-T-OE-047	[ECE] Speech & Audio Processing
BTCS-T-OE-041	[CSE] Internet Technology & Applications
BTCS-T-OE-042	[CSE] Advanced Java Programming

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

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 exergoinc reactions; Concept of Keq 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. Tamparo 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:

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3743984/https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4239820/
2. http://www.euro.who.int/data/assets/pdffile/0013/102316/e79822.pdf
3. https://www.tsijournals.com/articles/world-history-of-modern-biotechnology-and-its-applications.html
4. https://www.tandfonline.com/doi/full/10.1080/21553769.2016.1162753
5. 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 Microprocessors & Microcontrollers	L-T-P	Credits	Marks
PC	BTEC-T-PC-037		3-0-0	3	100

Objectives	The objective of this course is to study various microprocessors & microcontrollers, develop assembly-level programs, and interface with other external devices as per the requirements.
Pre-Requisites	Basic knowledge of Digital Electronics Circuit 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**: Introduction to 8085 microprocessor & its organization, general architecture, Bus organization, Memory concepts, Pins and Signals, Instruction execution, Timing diagram, Instruction Set & programming, Addressing modes, interrupts, memory & I/O interfacing.	**9 Hours**
Module-2	**Intel 8086 Microprocessor**: Bus Interface unit, Execution Unit, Register Organization, Memory Segmentation, Pin architecture, Minimum and Maximum mode system configuration, Physical Memory Organization, Interrupts, Addressing Modes, Instructions.	**8 Hours**
Module-3	**The 8051 Microcontroller**: Introduction to Microcontroller, CISC and RISC Processors, MCS-51 Architecture, Registers in MCS-51, 8051 Pin Description, Memory Organization, 8051 Addressing Modes, MCS-51 Instruction Set, 8051 Instructions and Simple Programs, Interrupts in MCS-51, Special function Registers, Assembly language programming.	**9 Hours**
Module-4	**Microcontroller Applications**: 8051 Timers and Counters, Serial Communication, I/O Interfacing using 8255, Light Emitting Diodes (LEDs), Push Buttons, Relays and Latch Connections.	**8 Hours**
Module-5	**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**
	Total	**42 Hours**

Text Books:

T1. M. Rafiquzzaman, ***Microprocessors and Microcomputer based System Design***, 2nd Edition, UBS Publications, 2001.

T2. K. M. Bhurchandi and A. K. Ray, ***Advanced Microprocessors and Peripherals***, 3rd Edition, McGraw-Hill Education,2012.

T3. M. A. Mazidi, J. G. Mazidi, and R. D. McKinlay, ***The 8051 Microcontroller and Embedded Systems : Using Assembly and C***, 2nd Edition, Pearson Education, 2011.

Reference Books:

R1. R. S. Gaonkar, ***Microprocessor Architecture, Programming, and Applications with the 8085***, 6th Edition, Penram International Publishing, 2013.
R2. B. Ram, ***Fundamentals of Microprocessors and Microcontrollers***, 9th Edition, Dhanpat Rai Publications, 2019.
R3. K. Ayala, ***The 8086 Microprocessor : Programming & Interfacing the PC***, 1st Edition, Delmar Cengage Learning, 2007.

Online Resources:

1. https://nptel.ac.in/courses/106108100/: by Prof. K. Kumar, IISc Bangalore
2. https://nptel.ac.in/courses/108/107/108107029/: by Dr. P. Agarwal, IIT Roorkee
3. https://nptel.ac.in/courses/108/105/108105102/: by Prof. S. Chattopadhyay, IIT Kharagpur

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

CO1	Explain the architecture, pins & signals, programming model, instruction execution of 8085 microprocessor and its interfacing with memory and I/O devices.
CO2	Describe the architecture, modes of operation, memory organization, interrupts of 8086 microprocessor and its interfacing with 8255 PPI and 8257 DMA controller.
CO3	Explain the concepts of embedded ICs, RISC and CISC processors and 8051 microcontroller to solve simple problems using assembly language programming.
CO4	Design microcontroller based interfacing for various applications.
CO5	Demonstrate peripheral interfacing with advanced programming of microprocessors and microcontrollers for real-time 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.
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	1	1
CO2	3	3	2	3	3							1	3	2	1
CO3	3	3	2	2	3								3	2	1
CO4	3	3	2	2	2							1	3	3	2
CO5	2	2	3	2	3				2	2			2	3	1

Type	Code	Instrumentation Devices & Systems	L-T-P	Credits	Marks
PC	BTEI-T-PC-005		3-0-0	3	100

Objectives	The objective of this course is to study the principles & applications of various sensors for the measurement of physical & electrical parameters, analyze the output, and do the appropriate/necessary conversions.
Pre-Requisites	Knowledge of physics, mathematics, basic electrical & 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	Acceleration Measurement: Piezoelectric transducers - Basic principle, equivalent circuit, frequency response, charge amplifier; Accelerometers: Basic principle & frequency response, MEMS Accelerometer, Gyro Accelerometer and their applications; Miscellaneous Measurements: Level measurements using floats, Hydrostatic pressure gauge, Capacitive type principles, Ultrasonic and Gamma ray type level indicators.	**10 Hours**
Module-2	Humidity Sensor: Capacitive & Resistive types; pH and Liquid Conductivity Measurement: Basic principles; Viscosity Measurement: Basic principles, Problems based on level, Hydrostatic pressure measurement; Chemical Sensors: For gas and humidity measurements - electronic (resistive, capacitive, FET), electro-chemical, intelligent ("smart") sensor systems & their structure, properties & applications, primarily data processing, diagnostics and auto-calibration.	**10 Hours**
Module-3	Signal Conditioning Elements: Deflection bridges - design of resistive and reactive bridges, push-pull configuration for improvement of linearity and sensitivity; Amplifiers: Operational amplifiers - Ideal and non-ideal performances, Inverting, Non-inverting and Differential amplifiers, Instrumentation amplifier, Isolation amplifier, Analog filters, Charge amplifier design, AC carrier systems, Phase sensitive demodulators and its applications.	**10 Hours**
Module-4	Data Acquisitions and Conversion: Introduction, Objective of DAS, Single channel DAS, Multi channel 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).	**7 Hours**
Module-5	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.	**5 Hours**
	Total	**42 Hours**

Text Books:

T1. J. P. Bentley, ***Principles of Measurement Systems***, 4th Edition, PHI, 2005.
T2. A. K. Ghosh, ***Introduction to Measurement and Instrumentation***, 3rd Edition, PHI Learning, 2009.
T3. C. D. Johnson, ***Process Control Instrumentation Technology***, 8th Edition, PHI Learning, 2014.

Reference Books:

R1. D. Patranabis, ***Sensors and Transducers***, 2nd Edition, PHI, 2013.
R2. B. G. Lipták, ***Instrument Engineers' Handbook (Process Measurement and Analysis)***, 4th Edition, CRC Press, 2003.
R3. E. O. Doebelin, ***Measurement Systems Application and Design***, 4th Edition, McGraw-Hill, 1990.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105062/: by Prof. S. Sen and Prof. S. Mukhopadhyay, IIT Kharagpur
2. 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	Measure acceleration & level using different types of accelerometers & level sensors.
CO2	Describe the principles and applications of humidity and chemical sensors.
CO3	Analyze signal conditioning elements like AC/DC bridge and OpAmps to get the output.
CO4	Understand various data acquisition & signal processing elements used in industry.
CO5	Present the measured data using various presentation elements in user-friendly manner.

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	2	1	1	1	2								2	2	
CO2	2	1	1	2	1	1	1						2	2	
CO3	2	3	1	1	1	1						1	1	2	1
CO4	2	2	2	1	1							1			3
CO5	2	2	1	1	1										2

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, Network Function Virtualization, Need for IoT Systems Management, Simple Network Management Protocol, Limitations of SNMP, Network Operator Requirements, NETCONF, YANG, IoT Systems management with NETCONF YANG, IoT Design Methodology.	**9 Hours**
Module-2	**IoT Strategies**: Networking, Communication, Adaptive & Event Driven Processes, Virtual Sensors, Security, Privacy & Trust, Low power communication, Energy harvesting, IoT related standardization; IoT Protocols: MQTT, CoAP, AMQP, JMS, DDS, REST, XMPP.	**8 Hours**
Module-3	**Sensors & Signal Conversion**: Sensors for Temperature, Humidity, Pressure, Liquid Level, Vibration; Photo-electric Sensors, Conductive type sensor; Signal conditioning & interfacing; Python Programming: Data Types, Control Flow, Functions, Modules, Packages, File Handling, Date/Time Operation, Classes.	**8 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.	**9 Hours**
Module-5	**Introduction to Data Analytics**: Introduction to Apache Hadoop: MapReduce, Hadoop ClusterSetup, YARN, Oozie, Spark, Kafka, Apache Storm; IoT Case Studies: Home Automation, Structural Health Monitoring, Weather Monitoring System, Air Pollution Monitoring, Smart Irrigation, Smart Healthcare, Smart Grid, Renewable Energy Systems, Smart Retail, Smart Machine Diagnosis & Prognosis.	**8 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. O. Vermesan and P. Friess (Ed.), ***Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems***, River Publishers, 2013.
T3. M. Schwartz, ***Internet of Things with Arduino Cookbook***, Packt Publishing, 2016.
T4. A. K. Ghosh, ***Introduction to Measurement and Instrumentation***, 3rd Edition, PHI Learning, 2009.

Reference Books:

R1. D. Hanes, G. Salgueiro, P. Grossetete, R. Barton, and J. Henry, ***IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things***, Cisco Press, 2017.
R2. D. Kellmereit and D. Obodovski, ***The Silent Intelligence: The Internet of Things***, 1st Edition, Lightning Source Inc., 2013.
R3. A. McEwen and H. Casimally, ***Designing the Internet of Things***, 1st Edition, Wiley, 2014.

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 IoT deployment strategies and communication protocols.
CO3	Describe the concepts of sensors, interfacing methodologies and their application to IoT.
CO4	Develop programs for IoT Applications using Arduino and Raspberry Pi.
CO5	Develop IoT solutions for specific applications and perform 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.

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	1	1	2	1									1		
CO2	2	2	2	1	2								2		
CO3	3	2	3	1	3								3		
CO4	3	3	3	1	3							1	3		1
CO5	3	3	2	2								1	2		1

Type	Code	Optoelectronic Devices & Instrumentation	L-T-P	Credits	Marks
PE	BTEE-T-PE-051		3-0-0	3	100

Objectives	The objective of this course is to study different optoelectronic devices & sensors and their applications in different fields.
Pre-Requisites	Basic knowledge of semiconductor materials and diodes 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	**Ray Optics**: Introduction to optoelectronics and its application, Basic optical laws and definitions, Total internal reflection, Numerical aperture, Ray propagation in step index fiber and graded index fiber.	**8 Hours**
Module-2	**Wave Optics**: Wave properties of light - Polarization, Interference, Diffraction; Transmission of light through wave guide - Maxwell's Equation; Losses - Attenuation, Dispersion, Bending Loss, Scattering.	**10 Hours**
Module-3	**Optical Sources and Detectors**: LED and Lasers - fundamentals; Light Emitting Diodes (LED): Materials for LED, Types of LEDs and their structure, Quantum efficiency, Output Power; Laser Diode: Laser fundamentals, Absorption and emission of radiation, Conditions for amplification by stimulated emission, Threshold condition for laser oscillation, Resonant frequencies, Quantum efficiency, Semiconductor laser; Photodiodes: PN, PIN, APD.	**10 Hours**
Module-4	**Fiber Optic Components**: Coupler and its classification, Splicer, Power loss in joining technique, Connector, Polarizer, Power coupled to a fiber.	**5 Hours**
Module-5	**Fiber Optic Sensors**: Classification of sensors, Intensity modulated sensors, Macro-bend, Micro-bending, Diffraction grating based IM sensors, Displacement sensors, Phase modulated sensor, Interferometric sensors, Fiber based Fabrey-Parot interferometric sensors, Sagnac effect based optical gyroscope, FBG sensor, Phase & polarization modulation based fiber sensors, Fiber optic gyroscope, Distributed fiber optic sensors - OTDR & OFDR principles.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. R. P. Khare, ***Fiber Optics & Optoelectronics***, 1st Edition, Oxford University Press, 2004.
T2. G. Kaiser, ***Optical Fiber Communication***, 5th Edition, McGraw Hill Education, 2013.

Reference Books:

R1. J. P. Bentley, ***Principles of Measurement Systems***, 4th Edition, Pearson Education, 2009.
R2. A. Ghatak and K. Tyagrajan, ***Introduction to Fiber Optics***, 1st Edition, Cambridge University Press, 1998.

R3. J. M. Senior, ***Optical Fiber Communications: Principles and Practice***, 3rd Edition, Pearson Education, 2009.

Online Resources:

1. https://nptel.ac.in/courses/117104127/: by Dr. P. Kumar K, IIT Kanpur
2. https://nptel.ac.in/courses/108104113/: by Dr. P. Kumar K, IIT Kanpur
3. https://nptel.ac.in/courses/117/101/117101054/: by Prof. D. K. Ghosh and Prof. R. K. Shevgaonkar, IIT Bombay
4. https://nptel.ac.in/courses/117/101/117101002/: by Prof. R. K. Shevgaonkar, IIT Bombay
5. https://ocw.mit.edu/resources/res-6-005-understanding-lasers-and-fiberoptics-spring-2008/fiberoptics-fundamentals/

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

CO1	Describe the fundamentals, advantages and advances in optical communication systems.
CO2	Understand the basic operating principles of various optoelectronic devices.
CO3	Compare the characteristics of optical fibers and losses during signal transmission.
CO4	Explain the technical details of various LEDs, LASER, and detectors.
CO5	Describe different optical sensors and their application in different fields.

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	2	3										2	1	1
CO2	3	3	3	1									2	2	1
CO3	3	2	2	2									1	2	
CO4	2	2	2	2									2	1	2
CO5	3	2	3	2								1	3	2	2

Type	Code	Energy Conversion Devices	L-T-P	Credits	Marks
PE	BTEE-T-PE-038		3-0-0	3	100

Objectives	The objective of the course is to study various types of electrical machines, their performance, control mechanisms, and industrial applications.
Pre-Requisites	Knowledge of basic electrical engineering, basic mathematics like calculus, and 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 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	**DC Machines**: Basics of rotating machines, Constructional Features, Methods of Excitation, Expression for EMF Induced and Torque Developed; DC Generators: No Load Characteristics for Separately Excited DC Generator and DC Shunt Generator, Conditions for Self Excitation, Critical Resistance and Critical Speed, Losses and Efficiency; DC Motors: Types of DC motors, Speed control of DC shunt motors, Starting of DC motors.	**10 Hours**
Module-2	**Transformers**: Constructional Features, EMF Equation, Equivalent Circuit, Determination of Parameters From Tests (Open Circuit Test and Short Circuit Test), Losses and Efficiency, Basics of 3-phase transformer, Introduction to Auto Transformer.	**8 Hours**
Module-3	**3-Phase Induction Motors**: Constructional Features of Squirrel Cage Rotor type and Slip Ring/Wound Rotor type induction motors, Principles of Operation, Concept of Slip, Slip vs. Torque Characteristics, Starting and Speed Control of Induction Motors.	**10 Hours**
Module-4	**Synchronous Machines**: Constructional Features, Types and Principles of operation as Alternator, EMF equation of alternator and phasor diagram, Voltage regulation by EMF method, Starting of Synchronous Motors.	**8 Hours**
Module-5	**Single Phase Motors**: Principles of Single phase Induction motors, Stepper motor, AC & DC Servo motors and their applications, BLDC motors.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. A. E. Fitzgerald, C. Kingsley Jr., and S. D. Umans, ***Electric Machinery***, 6th Edition, McGraw-Hill Education, 2017.
T2. S. J. Chapman, ***Electric Machinery and Fundamentals***, 4th Edition, McGraw-Hill Education, 2017.

Reference Books:

R1. P. S. Bimbhra, ***Electrical Machinery***, 7th Edition, Khanna Publishers, 2009.
R2. D. P. Kothari and I. J. Nagrath, ***Electric Machines***, 4th Edition, Tata McGraw-Hill, 2010.
R3. A. Husain and H. Ashfaq, ***Electrical Machines***, 3rd Edition, Dhanpat Rai & Co., 2016.

R4. J. B. Gupta, ***Theory & Performance of Electrical Machine***, 14th New Edition, S. K. Kataria & Sons Publication, 2015.

Online Resources:

1. https://nptel.ac.in/courses/108105017/: by Dr. D. Kastha, IIT Kharagpur
2. https://nptel.ac.in/courses/108106072/: by Prof. K. Vasudevan, Prof. G. S. Rao, Prof. P. S. Rao, IIT Madras
3. https://nptel.ac.in/courses/108/102/108102146/: by Prof. G.Bhuvaneshwari, IIT Delhi
4. https://nptel.ac.in/courses/108/105/108105155/: by Prof. T. K. Bhattacharya, IIT Kharagpur
5. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-685-electricmachines-fall-2013/

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

CO1	Explain the construction and operation of DC machines and analyze their performance characteristics.
CO2	Describe the operating principles of transformers and determine their circuit parameters & efficiency.
CO3	Describe the construction, operation, performance, starting and speed control of 3-phase induction machines.
CO4	Describe the construction and analyze performance of synchronous generators and motors.
CO5	Explain the construction, operation and performance of single phase induction motors and special 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.
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	3	2	2	1	1						1	3	1	
CO2	3	3	2	1	2	2						1	2		
CO3	3	3	3	2	2	3						1	2	1	1
CO4	3	2	3	1	1	3						2	3		
CO5	3	3	2	2	1	3						1	3	1	1

Type	Code	Computer Organization & Architecture	L-T-P	Credits	Marks
PE	BTCS-T-PE-019		3-0-0	3	100

Objectives	The objective of this course is to familiarize students about hardware design including logic design, basic structure and behaviour of the various functional modules of a modern digital computer and how they interact to provide the processing power to fulfil the needs of the user.
Pre-Requisites	Knowledge of basic digital electronics and computer fundamentals 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 structures of Computers: Computer Architecture vs. Computer Organization, Functional units, Operational concepts, Registers, Bus Structure, Performance Consideration, SPEC rating.	**9 Hours**
Module-2	Memory location and addresses, Big-endian and Little-endian representation, Instruction format, Instruction set Architecture, RISC vs. CISC, Addressing modes, Instruction Sequencing, Subroutines.	**8 Hours**
Module-3	Binary Arithmetic: Addition and subtraction of signed numbers, Design of fast adders, Multiplication of positive numbers, Signed operand multiplication, Fast multiplication, Integer division, Representation of floating point numbers.	**8 Hours**
Module-4	Memory System: Basic Concepts, Speed, Size and cost, Cache memory concepts, Cache memory mapping techniques, Performance consideration; Virtual memory concepts, Translation look-aside buffer, Replacement techniques, Secondary Storage.	**9 Hours**
Module-5	Basic Processing Units: Fundamental concepts, Execution cycle, Single-Bus and Multi-Bus Organization, Execution of complete instruction, Hardwired control, Micro programmed control, Accessing I/O devices.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. C. Hamacher, Z. Vranesic, and S. Zaky, ***Computer Organization***, 5th Edition, McGraw-Hill, 2017.
T2. W. Stallings, ***Computer Organization and Architecture***, 9th Edition, Prentice Hall India, 2012.

Reference Books:

R1. M. M. Mano, ***Computer System Architecture***, 3rd Edition, Pearson Education, 2007.
R2. B. Govindarajalu, ***Computer Architecture and Organization***, 5th Edition, Tata McGraw-Hill, 2004.
R3. N. P. Carter, ***Schaum's Outline of Computer Architecture***, McGraw-Hill Education, 2002.

Online Resources:

1. https://nptel.ac.in/courses/106103068/
2. https://nptel.ac.in/courses/106103180/

3. https://nptel.ac.in/courses/117105078/
4. https://www.cse.iitk.ac.in/users/karkare/courses/2011/cs220/html/notes.html
5. https://homepage.cs.uiowa.edu/~ghosh/6012.html

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

CO1	Explain the architectural concepts of a digital computer, identify various functional units and describe their functionality.
CO2	Represent instructions in various formats and solve problems based on addressing modes.
CO3	Perform various binary arithmetic operations using different techniques and represent floating point numbers and perform various operations on them.
CO4	Explain the working principle of Main memory, Cache memory and Virtual memory organization and solve numerical problems based on memory management.
CO5	Describe the working mechanism of the components of processing unit and discuss the techniques to enhance the performance.

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	3	2							1	2		3
CO2	3	3	2	3	1							1	2	1	2
CO3	3	3	3	2	2							1	2	1	2
CO4	2	3	3	2	1							1	3	2	3
CO5	2	3	3	2	1							1	1		1

Type	Code	System Design Using Verilog	L-T-P	Credits	Marks
PE	BTEI-T-PE-008		3-0-0	3	100

Objectives	The objective of this course is to provide in-depth knowledge on the Verilog HDL techniques for the design and analysis of various digital circuits & systems.
Pre-Requisites	Knowledge on digital electronic circuits and MOSFET 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 & 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	**Hierarchical Modeling Concepts**: Modules, Instances,Basic Concepts: Lexical Conventions, Whitespace, Comments, Operators; Data Types: Value Set, Nets, Registers, Vectors, Arrays, Parameters, Strings; Modules and Ports: Modules, Port Declaration, Port Connection Rules, Connecting Ports to External Signals.	**8 Hours**
Module-2	**Combinational Circuit Design-I**: Dataflow Modelling: Continuous Assignments, Delays, Expressions, Operators, and Operands, Operator Types, Examples; Gate-Level Modelling: Gate Types, Gate Delays, Rise, Fall, and Turn-off Delays, Min/Typical/Max Values; Switch-Level Modeling: Switch-Modeling Elements: MOS Switches, CMOS Switches, Bidirectional Switches, Power and Ground, Resistive Switches.	**9 Hours**
Module-3	**Combinational Circuit Design-II**: Behavioral Modeling: Initial Statement, Always Statement, Adders, Subtractors, Comparator, MUX and DeMUX (using `if...else` and `case` constructs); Loops: While Loop, For Loop, Repeat Loop, Forever loop (with relevant examples); Structural Modelling: 4-bit Adders, 2-bit Multiplier, 4-bit Comparator, 8:1-MUX and 1:8-DeMUX.	**9 Hours**
Module-4	**Multiplexer as Universal Logic**: Design of basic gates, Boolean expressions, and other combinational Logic circuits using Multiplexers; Decoders and Encoders: 1:2 Decoders, 2:4 Decoder, Test bench of Decoder, Priority Encoders, Test bench of Priority Encoder.	**8 Hours**
Module-5	**Sequential Design**: Sequential Logic, D Latch, Flip-Flop, Positive and negative Edge-Triggered D Flip-Flop, Synchronous and Asynchronous Reset; Counter Design Using Synthesizable Constructs: Synchronous Counters, Asynchronous counter, BCD Up–Down Counter.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Palnitkar, ***Verilog HDL: A guide to Digital Design and Synthesis***, 4th Edition, SunSoft Press, 1996.
T2. S. Brown, Z. Vranesic, ***Fundamentals of Digital Logic with Verilog Design***, 3rd Edition, McGraw Hill, 2013.

T3. K. Mishra, ***Advanced Chip Design: Practical Examples in Verilog***, 1st Edition, Createspace Independent Publishers, 2013.

Reference Books:

R1. V. Taraate, ***Digital Logic Design Using Verilog***, 2nd Edition, Springer, 2016.
R2. S. Ramachandran, ***Digital VLSI Systems Design***, 2nd Edition, Springer, 2006.
R3. C. H. Roth Jr., L. K. John, B. K. Lee, ***Digital Systems Design Using Verilog***, 2nd Edition, Cengage Learning, 2015.
R4. D. E. Thomas, P. R. Moorby, ***The Verilog Hardware Description Language***, 5th Edition, Kluwer Academic Publishers, 2002.

Online Resources:

1. https://nptel.ac.in/courses/108103179
2. https://www.chipverify.com/verilog/verilog-tutorial
3. https://www.javatpoint.com/verilog
4. https://www.edaplayground.com/

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

CO1	Become familiar with basic concepts and syntaxes of Verilog HDL.
CO2	Analyze and design combinational logic circuits using dataflow, gate level and switch level modelling of Verilog.
CO3	Analyze and design combinational logic circuits using behavioral and structural modelling of Verilog.
CO4	Design combinational logic circuits using multiplexer as universal logic through Verilog HDL.
CO5	Analyze and design sequential logic circuits through Verilog HDL using synthesizable constructs.

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.

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	1							2	1	1
CO2	2	2	3	2	3	1							2	2	1
CO3	2	2	3	2	3	1							2	3	2
CO4	1	3	3	3	2	1							1	3	2
CO5	1	3	3	3	2	1							1	3	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:

1. https://nptel.ac.in/courses/108/105/108105058/: by Prof. S. Banerjee, IIT Kharagpur
2. https://nptel.ac.in/courses/112/103/112103275/: by Prof. D. N. Basu, IIT Guwahati
3. 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.

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.

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	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 Uni-modal 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	Digital Communication	L-T-P	Credits	Marks
OE	BTEC-T-OE-999		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**: Source, Line coder, Multiplexer, Regenerative repeater, Sampling in transmitting 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 first 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	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	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	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	Teamsmanship & Leadership Skills 1 – Video.
15	Teamsmanship & 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	Fundamentals of Microprocessors & Microcontrollers Lab	L-T-P	Credits	Marks
PC	BTEC-P-PC-038		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	Program for arithmetic operations using 8085.
2	Program for finding the largest and smallest from a set of numbers using 8085.
3	Program for arranging numbers in ascending and descending order using 8085.
4	Programs for 16 bit arithmetic operations using 8086.
5	Programs for Sorting and Searching (using 8086).
6	Programs for String manipulation operations (using 8086).
7	Interfacing ADC and DAC.
8	Parallel Communication between two MP Kits using Mode-1 and Mode-2 of 8255.
9	Programming using Arithmetic, Logical and Bit Manipulation instructions of 8051 microcontroller.
10	Programming and verifying Timer, Interrupts and UART operations in 8051 microcontroller.
11	Interfacing and Programming of Stepper Motor and DC Motor Speed control.
12	Programming and verifying Timer, Interrupts and UART operations in 8051 microcontroller.
13	Communication between 8051 Microcontroller kit and PC.
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. M. Rafiquzzaman, ***Microprocessors and Microcomputer based System Design***, 2nd Edition, UBS Publications, 2001.

T2. K. M. Bhurchandi and A. K. Ray, ***Advanced Microprocessors and Peripherals***, 3rd Edition, McGraw-Hill Education, 2012.

T3. M. A. Mazidi, J. G. Mazidi, and R. D. McKinlay, ***The 8051 Microcontroller and Embedded Systems : Using Assembly and C***, 2nd Edition, Pearson Education, 2011.

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

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

CO1	Describe 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	Develop simple assembly level programs such as 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 the modes of operation of 8255 PPI and its interfacing with peripheral 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	1	1	1	1								2	1	
CO2	3	2	3	2	2							1	2	1	1
CO3	3	2	3	2	3								2	2	
CO4	3	2	3	3	3							1	3	1	1
CO5	3	2	2	2	2							1	2	1	1

Type	Code	Instrumentation Devices & Systems Lab	L-T-P	Credits	Marks
PC	BTEI-P-PC-006		0-0-2	1	100

Objectives	The objective of this laboratory course is to get practical exposure in designing of different measurement systems using various sensors, programming in LabVIEW, and acquiring the sensor data using DAQ card
Pre-Requisites	Knowledge of transducers & sensors, and LabVIEW is required. Topics taught in IDS 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 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	Design of a temperature measurement system with thermocouple providing cold junction compensation using LabVIEW and DAQ.
2	Design of a microcontroller based storage & display device.
3	Design of LVDT and its signal conditioning circuit using LabVIEW and DAQ.
4	Design of load cell using stain gauge and LabVIEW and DAQ.
5	Design of an orifice type flow meter with diaphragm type differential pressure transducer with capacitive sensing scheme.
6	Design of a piezoelectric accelerometer with charge amplifier configuration.
7	Design of active low pass, high pass & band pass filters.
8	Design of a stepper motor drive.
9	Design of Regulated power supply unit.
10	Embedded real-time system design using ARM controller.
11	Design of PID controller using LabVIEW and hardware design.
12	Design of pressure sensor using LabVIEW and DAQ.
13	Design of sound measurement using LabVIEW and DAQ.

Text Books:

T1. J. P. Bentley, ***Principles of Measurement Systems***, 4th Edition, PHI, 2005.
T2. A. K. Ghosh, ***Introduction to Measurement and Instrumentation***, 3rd Edition, PHI Learning, 2009.
T3. C. D. Johnson, ***Process Control Instrumentation Technology***, 8th Edition, PHI Learning, 2014.
T4. J. Travis and J. Kring, ***LabVIEW for Everyone: Programming Made Easy and Fun***, 3rd Edition, Prentice Hall, 2006.

Reference Books:

R1. D. Patranabis, ***Sensors and Transducers***, 2nd Edition, PHI Learning, 2013.
R2. D. V. S. Murthy, ***Transducers and Instrumentation***, 2nd Edition, PHI Learning, 2008.
R3. E. O. Doeblin, ***Measurement Systems - Applications and Design***, 6th Edition, McGraw Hill, 2007.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105062/: by Prof. S. Sen and Prof. S. Mukhopadhyay, IIT Kharagpur
2. 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	Design virtual instrumentation system for temperature measurement using LabVIEW and DAQ.
CO2	Design real-time position measurement using LVDT, LabVIEW and DAQ.
CO3	Implement real-time measurement systems using acceleration, pressure, flow sensors, LabVIEW and DAQ.
CO4	Design stepper motor drive, active low pass, high pass & band pass filters.
CO5	Design embedded real-time systems using ARM controller.

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.
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	3	1	1				1				2	2	2
CO2	2	2	3	1	1				1				1	2	1
CO3	2	3	2	1	2	1			1				1	2	2
CO4	2	3	3	1	3	1			1				2	1	2
CO5	1	1	2	2	2	1			1				2	1	1

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.icai.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	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	**High Speed CMOS Logic Design**: Introduction, Switching Time Analysis, Detailed Load Capacitance Calculation, Improving Delay Calculation with Input Slope, Calculation of Interconnect Parasitics, Calculation of Interconnect Delay (Elmore Delay), Gate Sizing for Optimal Path Delay, Optimizing Paths with Logical Effort, 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; **Design for Testability**: Introduction, Fault Types and Models, Built-In Self-Test (BIST) Techniques, Current Monitoring IDDQ Test.	**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. P. 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.
R5. J. P. Uyemura, ***Introduction to VLSI Circuits and Systems***, John Wiley & Sons, 2006.
R6. W. Wolf, ***Modern VLSI Design - System on Chip Design***, 3rd Edition, Pearson Education, 2004.

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.

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.
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	3	1	2	1	1	1				2	1	1		1
CO2	3	2		1	1								1		
CO3	2	3	3	1	1							1	2	1	2
CO4	2	1	2	2	1								1		1
CO5	2	2	3	2	1							1	2	1	2

Type	Code	Introduction to Digital Signal Processing	L-T-P	Credits	Marks
PC	BTEC-T-PC-035		3-0-0	3	100

Objectives	The objective of this course is to study various signals and systems in time & spectrum domains, investigate the stability & causality of systems, understand Z-transform, discrete Fourier transform and their properties, and to understand design of IIR & FIR filters.
Pre-Requisites	Knowledge of complex numbers and elementary calculus 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 & Systems: Introduction to Signal, Classification, Convolution of two signals (graphical & analytical); Introduction to System, Classification, Continuous-time & Discrete-time LSI system, System representation through differential & difference equations, Response of LSI system, Convolution Integral, Convolution Sum, Correlation of Discrete-time signals & its properties.	**10 Hours**
Module-2	Discrete Time Signals: Z-Transform, Region of convergence, Properties of Z-transform, Inverse Z-transform (power series & partial fraction methods); Analysis of LSI systems: causality and stability using Z-transform, pole-zero concept and pole-zero cancellation, transient and steady state response; Unilateral Z-transform and its properties, solution of difference equations.	**8 Hours**
Module-3	Discrete Fourier Transform: Basics of Discrete Time Fourier Transform (DTFT), frequency domain sampling and reconstruction of discrete time signals; Discrete Fourier Transform (DFT) and its properties; Linear filtering (overlap add method and overlap save method); Efficient computation of DFT: Fast Fourier Transform (FFT) Algorithm (Radix-2 DIT and Radix-2 DIF).	**8 Hours**
Module-4	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.	**8 Hours**
Module-5	Design of Digital Filters: Causality and its implication; Design of FIR filters: symmetric and anti-symmetric, design of Linear Phase FIR filters using Windowing technique and frequency sampling technique; Design of IIR Filters from analog filters using Impulse invariance and bilinear transformation techniques.	**8 Hours**
	Total	**42 Hours**

P.T.O

Text Books:

T1. A. V. Oppenheim, A. S. Willsky, and S. H. Nawab, ***Signals and Systems***, 2nd Edition, Prentice Hall India, 1992.
T2. B. P. Lathi, ***Principles of Signal Processing and Linear Systems***, 2nd Edition, Oxford University Press, 2009.
T3. J. G. Proakis and D. G. Manolakis, ***Digital Signal Processing : Principles, Algorithms and Applications***, 4th Edition, Prentice Hall India, 2007.
T4. S. K. Mitra, ***Digital Signal Processing : A Computer Based Approach***, 4th Edition, McGraw Hill, 2013.

Reference Books:

R1. A. Ambardar, ***Analog and Digital Signal Processing***, 2nd Edition, Brooks/Cole Publishing Company (an International Thomson Publishing Company), 1999.
R2. M. J. Roberts, ***Signals and Systems - Analysis using Transform Methods and MATLAB***, 2nd Edition, McGraw hill, 2003.
R3. A. N. Kani, ***Signals and Systems***, 2nd Edition, McGraw Hill Education, 2010.
R4. A. N. Kani, ***Digital Signal Processing***, 2nd Edition, McGraw Hill Education, 2012.
R5. P. R. Babu, ***Digital Signal Processing***, 4th Edition, SciTech Publication, 2011.

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/117101055/: by Prof. V. M. Gadre, IIT Bombay

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

CO1	Explain different types of signals and analyze various types of LSI systems responses.
CO2	Investigate the systems stability and causality using Z-Transform.
CO3	Analyze discrete signals and systems using DFT technique.
CO4	Realize different structures of FIR and IIR discrete time systems.
CO5	Design IIR and FIR 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.

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	1	2	1	2	2								2		
CO2	2	1	1	2	2	1							2	1	
CO3	2	1	1		1	1							1	1	
CO4	1	2	3	2	2	2							2	1	
CO5	2	2	2	1	1	2							2	1	

Type	Code	Advanced Sensor Technology	L-T-P	Credits	Marks
PE	BTEI-T-PE-009		3-0-0	3	100

Objectives	The objective of this course is to study various advanced sensing techniques and fiber optics sensors required for the measurement of non-electrical parameters in manufacturing processes & applications.
Pre-Requisites	Knowledge of physics, mathematics, basic electrical & electronics engineering, and transducers & measurement are 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	**Advanced Sensors in Manufacturing**: Types of sensors & control techniques, Photoelectric sensors, Detection methods, Proximity sensors (inductive & capacitive), Limit switches, Inductive & Capacitive sensors in manufacturing, Microwave-sensing applications, Infrared spectrum, Laser sensors.	**7 Hours**
Module-2	**Fiber Optics in Sensors & Control Systems**: Introduction, Photoelectric sensors for long-distance detection, Fiber optics, Inductive proximity sensors for non-contact metal detection, Limit switches, Factors affecting selection of position sensors, Wavelengths of commonly used LEDs, Sensor alignment techniques, Fiber optics in industrial communication & control.	**8 Hours**
Module-3	**Sensor Technology in Precision Manufacturing**: Identification of manufacturing components, Digital encoder sensors, Sensors detecting faults in dynamic machine parts (bearings), Sensors for vibration measurement of structures, Optoelectronic sensor tracking targets on a structure, Acousto-optical/electronic sensor, Synthetic-aperture radar utilizing vision technology, Optoelectronic/vision associative memory for high-precision image display & measurement, Ultrasonic stress sensor measuring dynamic changes in materials, Optical sensor quantifying acidity of solutions, Sensors for biomedical technology.	**10 Hours**
Module-4	**Nano/MEMS Sensors**: MEMS sensors in space test program satellite, Bulk micro machined accelerometers, Surface micro machined micro spectrometers, Current uses for MEMS devices in medical industry; **GMR Sensors**: GMR materials, Magnetic field sensors, Integrated GMR sensor, Potential of GMR sensor technology.	**8 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	**Application of Acoustic, Strain, and Optical Sensors in NDT**: Introduction, Acoustic emission testing, Strain gauge testing, Laser displacement gauge testing, TDR cable installation in new & existing columns; **Chemical & Gas Sensor Developments**: Introduction, Micro fabricated & micro machined sensors, Tin Oxide based sensors, Schottky diode–type sensors, Solid electrolyte calorimetric sensors, Electrochemical sensors.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Soloman, ***Sensors Handbook***, 2nd Edition, McGraw-Hill Education, 2010.
T2. M. Bhuyan, ***Intelligent Instrumentation - Principles and Applications***, 1st Edition, CRC Press, 2017.

Reference Books:

R1. J. P. Bentley, ***Principles of Measurement Systems***, 4th Edition, Pearson Education, 2005.
R2. A. K. Ghosh, ***Introduction to Measurement and Instrumentation***, 3rd Edition, PHI Learning, 2009.
R3. D. Patranabis, ***Sensors and Transducers***, 2nd Edition, PHI, 2010.
R4. D. V. S. Murthy, ***Transducers and Instrumentation***, 4th Edition, PHI, 2000.
R5. E. O. Doeblin, ***Measurement Systems, Applications and Design***, 4th Edition, McGraw Hill, 2007.

Online Resources:

1. https://nptel.ac.in/courses/108108147/: by Prof. H. J. Pandya, IISc Bangalore
2. https://nptel.ac.in/courses/108105064/: by Prof. A. Barua, IIT Kharagpur

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

CO1	Describe various advanced sensors used in manufacturing applications.
CO2	Explain the use of fiber-optic sensors and control systems in industrial applications.
CO3	Identify the sensing components in precision industrial manufacturing applications.
CO4	Understand the principle and construction of Nano/MEMS and GMR Sensors.
CO5	Visualize application of advanced sensor techniques in NDT and sensing of chemicals.

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	1	1										3		1
CO2	3	2	2	3								1	3	1	2
CO3	3	3	2	3								1	2	1	1
CO4	2	3	1	2								1	2	1	
CO5	2	2	3	1								1	2	1	2

Type	Code	Power Electronics	L-T-P	Credits	Marks
PE	BTEE-T-PE-018		3-0-0	3	100

Objectives	The objective of this course is to provide an overview of different types of power semiconductor devices and their switching characteristics along with the operation & characteristics of various types of power electronic converters.
Pre-Requisites	Knowledge of physics, basic mathematics, calculus, ordinary differential equations and basic 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	**Power Semiconductor Devices**: Switching and V-I characteristic of devices: Power diode, Transistor Family: BJT, IGBT, and MOSFET, Thyristor family: SCR, TRIAC; Series and parallel grouping of SCR, SCR triggering methods, Isolation of gate and base drive, SCR: Over voltage, Over Current, dv/dt, di/dt, Gate Protection, Snubber circuit, Commutation.	**10 Hours**
Module-2	**AC to DC Converter**: Principle of phase controlled converter operation, Single phase full converter with R, R-L, and R-L-E load, 3 phase full converter with R, R-L, and R-L-E load, Single phase semi converter with R, R-L, and R-L-E load, Effect of source inductance, Applications.	**10 Hours**
Module-3	**AC to AC Converter**: Single phase bi-directional controllers with R and R-L load, Single phase cycloconverters – Step up and Step down, Applications.	**6 Hours**
Module-4	**DC to DC Converter**: First quadrant, Second quadrant, First and second quadrant, Third and fourth quadrant converter. Switching mode regulators: Buck regulators, Boost regulators, Buck-Boost regulators, Isolated Converters, Applications.	**8 Hours**
Module-5	**DC to AC Converter**: Voltage Source Inverter (VSI): Single phase Bridge Inverters, 3-Phase Inverters - 180° mode conduction, 120° mode conduction, Voltage control of 3-Phase Inverters by Sinusoidal PWM (PWMVSI), Current Source Inverter (CSI); Applications: UPS, SMPS, Induction Heating, AC/DC drives speed control.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. M. H. Rashid, ***Power Electronics: Devices, Circuits, and Applications***, 4th Edition, Pearson Education, 2017.
T2. P. S. Bhimbra, ***Power Electronics***, 6th Edition, Khanna Publishers, 2014.

Reference Books:

R1. M. D. Singh and K. B. Khanchandani, ***Power Electronics***, 2nd Edition, McGraw-Hill, 2017.
R2. P. C. Sen, ***Power Electronics***, 1st Edition, McGraw Hill India, 2001.

Online Resources:

1. https://nptel.ac.in/courses/108/102/108102145/: by Prof. G. Bhuvaneshwari, IIT Delhi.
2. https://nptel.ac.in/courses/108/101/108101126/: by Prof. V. Agarwal, IISc Bangalore.
3. https://nptel.ac.in/courses/108/105/108105066/: by Dr. D. Kastha, Prof. S. Sengupta, Prof. N. K. De, and Prof. D. Prasad, IIT Kharagpur.
4. https://nptel.ac.in/courses/108101038/: by Prof. B. G. Fernandes and Prof. K. Chatterjee, IIT Bombay.

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

CO1	Describe the characteristics of Power semiconductor devices and thyristor family.
CO2	Explain, analyze, and design AC - DC converters for real-world applications.
CO3	Explain, analyze, and design AC - AC converters for real-world applications.
CO4	Explain, analyze, and design DC - DC converters for real-world applications.
CO5	Explain, analyze, and design DC – AC converters for real-world 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.
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	1							1	3	1	1
CO2	3	1	1	2	1							1	3	2	1
CO3	3	1	1	2	1							1	3	2	1
CO4	3	1	1	2	1							1	3	2	1
CO5	3	1	1	2	1							1	3	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 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); **Introduction to SPICE modeling**: 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.
T4. N. Weste and D. Harris, ***CMOS VLSI Design: A Circuits and Systems Perspective***, 4th Edition, Pearson Education, 2015.

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. Sedra and K.C. Smith, ***Microelectronic Circuits***, 5th Edition, Oxford University Press, 2004.
R4. W. M. Siebert, ***Circuits, Signals, and Systems***, 1st Edition, MIT Press, 1986.
R5. 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.

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.
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		
CO2	1	1		1	2							1	1		
CO3	2	2	3	1		1							2	1	1
CO4	2	3	3	2		1							2	1	1
CO5	2	3	3	2		1							2	1	1

Type	Code	PLC, Distributed Control Systems & SCADA	L-T-P	Credits	Marks
PE	BTEI-T-PE-052		3-0-0	3	100

Objectives	The objective of this course is to study programmable logic controllers, distributed control systems and SCADA to design & develop instrumentation system for automation of large scale process industries.
Pre-Requisites	Knowledge of electrical, electronics and computer programming is required.
Teaching Scheme	Regular class room 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	**Programmable Logic Controller (PLC)**: Definition, Historical background, Parts of a PLC, Principles of operation, PLCs vs. other types of controllers, PLC size & application, Advantages of PLCs; Developing Fundamental PLC Wiring Diagrams and Ladder Logic Programs: Electromagnetic control relays, Contactors, Motor starters, Manually & Mechanically operated switches, Sensors, Output control devices, Seal-in circuits, Electrical interlocking circuits, Converting relay schematics into PLC ladder programs, Ladder Logic Program from a narrative description.	**8 Hours**
Module-2	**PLC Programming**: Introduction, Types of PLC languages, Ladder diagram format, Ladder relay instructions, Ladder relay programming, Timers and counters, Program/Flow control instructions, Arithmetic instructions, Data manipulation, Data transfer instructions & special function instructions, Network communication instructions; PLC Installation Practices, Editing, and Troubleshooting: PLC enclosures, Electrical noise, Leaky inputs and outputs, Grounding, Voltage variations & surges, Program editing and commissioning, Programming & monitoring, Preventive maintenance, Troubleshooting, PLC programming software.	**9 Hours**
Module-3	**Introduction to SCADA**: Data acquisition systems, Evolution of SCADA, Communication technologies, Monitoring and supervisory functions, SCADA applications in utility automation, Industries; SCADA System Components: Schemes - Remote terminal unit, Intelligent electronic devices, Programmable Logic Controller, Communication Network, SCADA Server, SCADA/HMI Systems; SCADA Applications: Utility applications - Transmission & distribution sector – operations, monitoring, analysis and improvement, Industries - oil, gas and water, Case studies, Implementation, Simulation exercises.	**9 Hours**
Module-4	**Distributed Control Systems (DCS)**: Introduction, History of DCS, DCS concept, Communication in DCS, Modes of DCS, DCS hardware & software, DCS structure, Architectural feature of DCS, DCS design considerations, Advantages & disadvantages.	**7 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	**System Integration with PLC & Computer**: Supervisory computer functions - Supervisory control and optimization, production monitoring and control, on-line information system; DCS and Supervisory Computer Displays: Display access method, Display features, Alarm access architecture, Voice input machine interface; Man Machine Interface: Sequencing, Supervisory control; Computer Interface with DCS Hardware: Gateway, Interface with PLC, Interface with direct I/O, Network linkages, Links between networks.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. F. D. Petruzella, ***Programmable Logic Controllers***, 5th Edition, McGraw-Hill Education, 2017.
T2. S. A. Boyer, ***SCADA - Supervisory Control and Data Acquisition***, 3rd Edition, Instrument Society of America, 2004.
T3. S. Bhanot, ***Process Control: Principles and Applications***, 1st Edition, Oxford University Press, 2008.

Reference Books:

R1. L. A. Bryan and E. A Bryan, ***Programmable Controller: Theory and Implementation***, 3rd Edition, Industrial Text Company Publication, 2003.
R2. D. H. Hanssen, ***Programmable Logic Controller: A Practical Approach to IEC61131-3 using CoDeSys***, 1st Edition, John Wiley & Sons, 2015.
R3. K. P. Raju and Y. J. Reddy, ***Instrumentation and Control System***, McGraw-Hill Education, 2017.
R4. B. G. Liptak, ***Process Control: Instrument Engineers Handbook***, 4th Edition, The Instrumentation Systems and Automation Society, 2006.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105063/: by Prof. S. Mukhopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/108/105/108105088/: by Prof. S. Mukhopadhyay, IIT Kharagpur
3. https://nptel.ac.in/courses/108/105/108105062/: by Prof. S. Sen and Prof. S. Mukhopadhyay, IIT Kharagpur
4. https://www.youtube.com/watch?v=_d0UZro2Ajo: by by Mr. P. Raverkar (Siemens)

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

CO1	Experiment with the wiring diagram of PLC with various sensors & output devices and execute different ladder programs.
CO2	Develop programs for PLC based processes and their maintenance as per requirement.
CO3	Effectively utilize SCADA systems in transmission & distribution sector.
CO4	Design and construct DCS with required hardware and software for industrial applications.
CO5	Integrate PLC, DCS, and SCADA systems to build automation systems for the industry.

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.
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	2	3	1						1	3	3	1
CO2	2	2	2	1	2	1						1	2	3	2
CO3	3	2	2	1	2	1						1	1	1	3
CO4	2	2	1	2	2	1						1	1	2	2
CO5	2	2	3	2	3	1						1	3	3	2

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 Willey & 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. Mukhopadhya, 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	
CO2	1	1	2	3	1			2					2	1	
CO3	2	2	1	2		1	2	2					1		
CO4	2	1	2	2		1		3					2		
CO5	3	2	2	1		1	2	1					1		

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; Kohenen 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. Karry 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. Pratihar, 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.

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	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	Virtual Instrumentation	L-T-P	Credits	Marks
PE	BTEI-T-PE-017		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.	**7 Hours**
Module-2	**VI Programming**: FOR and WHILE Loops, Additional loop problem, Loop behaviour & 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: Arrays, Clusters, Inter-conversion of arrays & clusters; Graphs & Charts: Waveform chart, Resetting plots, Waveform graph, Use of cursors, X-Y graph; File Input/Output: File formats, File I/O functions, Path functions, Examples of file READ/WRITE; String Handling: String functions, LabVIEW string formats, Parsing of strings.	**10 Hours**
Module-3	**Data Acquisition**: Introduction, Sampling fundamentals, I/O techniques and buses, ADCs, DACs, Digital I/O, Counters and timers, DMA, Software & hardware installation, Calibration, Resolution; Data acquisition interfaces: Requirements, Issues involved in selection of data acquisition cards, Cards with serial communication, VI chassis requirements; PC Buses: Local busses - ISA, PCI, RS232, RS422, RS485; Interface Buses: USB, PCMCIA, VXI, SCXI, PXI; Instrumentation Buses: Modbus & GPIB, Networked buses, ISO/OSI reference model, Ethernet & TCP/IP Protocols.	**10 Hours**
Module-4	**VI Toolsets**: Use of analysis tools, Fourier transforms, Power spectrum, Correlation methods, Windowing and filtering, Application of VI in designing of process control equipment like Oscilloscope, Digital multimeter, Design of digital Voltmeters with transducer input Virtual laboratory, Web based laboratory.	**7 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	**Applications**: Distributed I/O modules, Instrument control, Development of process database management system, Simulation of systems using VI, Development of control system, Industrial communication, Image acquisition and processing, Motion control, Development of Virtual Instruments using GUI, Real-time systems, Embedded controller, OPC, HMI/SCADA software, Active-X programming.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. G. Johnson, ***LabVIEW Graphical Programming***, 4th Edition, McGraw Hill, 2006.
T2. J. Travis and J. Kring, ***LabVIEW for Everyone: Programming Made Easy and Fun***, 3rd Edition, Prentice Hall, 2006.

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 design of indigenous virtual instruments.
CO4	Demonstrate the use of virtual instrumentation tool sets.
CO5	Design and develop virtual instrumentation systems 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.

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	2	1	2	1	2	1							2		
CO2	2	2	3		2							1	2		1
CO3	3	1	2	1	2							1	2		1
CO4	1	1	2	1	2								1		
CO5	2	3	2	2	1	2						2	2		2

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 effectivenss 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	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	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	Advanced Communication Systems	L-T-P	Credits	Marks
OE	BTEC-T-OE-061		3-0-0	3	100

Objectives	The objective of this course is to study digital data transmission & modulation techniques, multiple accessing techniques, cellular communication, and fiber optic communication systems.
Pre-Requisites	Knowledge of analog communication, sampling theorem, and electromagnetic wave propagation 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	**Principles 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 first criterion for zero ISI, Multiplexer, Regenerative repeater, Scrambling, Companding, Digital receiver, Equalizers, Timing extraction, Detection error, and Eye Diagram.	**9 Hours**
Module-2	**Digital Modulation Techniques**: ASK, BFSK, BPSK, DPSK, QPSK, QAM, M-ary PSK, Baseband signal receiver, probability of error, Optimum filter, Matched filter, Correlator.	**9 Hours**
Module-3	**Multiple Access Techniques**: Frequency division multiple access, Time division multiple access, code division multiple access, OFDM and MIMO.	**8 Hours**
Module-4	**Digital Cellular Communication Systems**: Mobile communication, The GSM system, concept of a cell, A basic cellular network, CDMA system based on IS-95, Standards of mobile and personal communication systems.	**8 Hours**
Module-5	**Fiber Optic Communication**: A fiber-optical communication system, Advantages of fiber-optic systems, Optical fiber structure, Fiber types, Fundamental laws of optics, Total internal reflection, Numerical Aperture, Acceptance angle, Wave propagation in a cylindrical wave guides, Modal concept, V-number, Attenuation, and Dispersion in fiber, Dispersion shifted and dispersion flattened fiber.	**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. R. P. Singh and S. D. Sapre, ***Communication Systems: Analog and Digital***, 3rd Edition, McGraw-Hill Education, 2014.
T3. R. P. Khare, ***Fiber Optics and Optoelectronics***, Oxford University Press, 2004.

Reference Books:

R1. B. P. Lathi and Z. Ding, ***Modern Digital and Analog Communication Systems***, 4th Edition, Oxford University Press 2010.
R2. B. Sklar and P. K. Ray, ***Digital Communications – Fundamentals and Applications***, 2nd Edition, Pearson Education, 2009.

Online Resources:

1. https://nptel.ac.in/courses/117/105/117105143/: by Prof. G. Das, IIT Kharagpur
2. https://nptel.ac.in/courses/108/102/108102120/: by Prof. A. Dixit, IIT Delhi
3. https://nptel.ac.in/courses/117/105/117105144/: by Prof. S. S. Das, IIT Kharagpur
4. https://nptel.ac.in/courses/108/102/108102096/: by Prof. S. Prasad, IIT Delhi

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

CO1	Describe the basic principles of digital data transmission.
CO2	Explain & analyze different digital modulation techniques.
CO3	Analyze & solve problems related to different multiple access techniques.
CO4	Explain the fundamentals & standards of cellular communication systems.
CO5	Describe the principles of communication through a fiber optic medium.

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	2	2							1	3	1	1
CO2	3	3	3	2	3							1	3		1
CO3	3	3	3	3	3							1	3	2	
CO4	3	2	2	3	3							1	2	1	
CO5	3	3	2	2	3							1	2	1	

Type	Code	Speech & Audio Processing	L-T-P	Credits	Marks
OE	BTEC-T-OE-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	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	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 Full adder.
5	Design a schematic and simple layout for MUX, DeMUX.
6	Design a schematic and simple layout for D flip-flop.
7	Design a schematic and simple layout for simple and complex Boolean expressions.
8	Design a schematic and simple layout for dynamic logic implementation (Domino logic).
9	Design a schematic and simple layout for dynamic logic implementation (NORA logic).
10	Design 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 with display of the sum on 7-Segment Display.
12	Design, Test Bench Creation and Simulation of Full Subtractor and its FPGA Implementation with display of the difference on 7-Segment Display.
13	Design, Test Bench Creation and Simulation of 4:1 Mux & 1:4 DeMux and its FPGA Implementation.
14	Design, Test Bench Creation and Simulation of 4 bit up/down Counter and its FPGA Implementation.

Cont'd...

Experiment-#	Assignment/Experiment
15	Design, Test Bench Creation and Simulation of 4 bit Shift Register and its FPGA Implementation.
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. P. 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.
R5. J. P. Uyemura, ***Introduction to VLSI Circuits and Systems***, John Wiley & Sons, 2006.
R6. W. Wolf, ***Modern VLSI Design - System on Chip Design***, 3rd Edition, Pearson Education, 2004.

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.

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.
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	Introduction to Digital Signal Processing Lab	L-T-P	Credits	Marks
PC	BTEC-P-PC-036		0-0-2	1	100

Objectives	The objective of the lab course is to perform basic signal processing operations such as linear & circular convolution, auto & cross correlation, frequency analysis, and implementation of FIR & IIR filters using MATLAB.
Pre-Requisites	Basic knowledge of Signals & systems and MATLAB programming are required to conduct the experiments.
Teaching Scheme	Regular laboratory experiments conducted under supervision of the teacher. Demonstration along with associated safety measures will also be explained.

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 circular 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	Convolution of long duration sequences using overlap add, overlap save method 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 window, triangular window and Kaiser window) using MATLAB.
10	Design and implementation of IIR (lowpass and highpass) Filters (Butterworth and Chebyshev) using 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. S. K. Mitra, ***Digital Signal Processing : A Computer Based Approach***, 4th Edition, McGraw Hill, 2013.
T3. A. V. Oppenheim, A. S. Willsky, and S. H. Nawab, ***Signals and Systems***, 2nd Edition, Prentice Hall India, 1992.

Reference Books:

R1. A. N. Kani, ***Signals and Systems***, 2nd Edition, McGraw Hill Education, 2010.

R2. P. R. Babu, ***Digital Signal Processing***, 4th Edition, SciTech Publication, 2011.
R3. R. Pratap, ***Getting Started with MATLAB : A Quick Introduction for Scientists & Engineers***, 1st South Asia Edition, Oxford University Press, 2010.
R4. S. S. Kumar and S. V. B. Lenina, ***MATLAB: Easy Way Of Learning***, 1st Edition, PHI Learning, 2016.
R5. L. R. Rabiner and B. Gold, ***Theory and Application of Digital Signal Processing***, 2nd Edition, Prentice Hall India, 1992.
R6. J. R. Johnson, ***Introduction to Digital Signal Processing***, 2nd Edition, Prentice Hall India, 1992.

Online Resources:

1. https://ocw.mit.edu/resources/res-6-008-digital-signal-processing-spring-2011
2. https://digitaldefynd.com/best-digital-signal-processing-courses
3. http://www.dspguide.com/pdfbook.htm: online book by Prof. S. W. Smith
4. https://dspguru.com: contains links to various resources on DSP

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

CO1	Understand the generation of various elementary signals in MATLAB.
CO2	Perform basic signal processing operations like convolution, correlation etc.
CO3	Analyze the spectrum of discrete time signals using DFT.
CO4	Implement various efficient computation techniques using FFT-DIT and FFT-DIF algorithms.
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	2	
CO4	2	1	3	3	2	3							3	2	
CO5	3	2	1	1	2	2							2	2	

Type	Code	Skill Lab & Project-I	L-T-P	Credits	Marks
PJ	BTEI-P-PJ-010		0-0-4	2	100

Objectives	The objective of the laboratory course is to impart additional skills in circuit analysis using SPICE tools, PCB design using EDA tools, grounding & shielding, signal conditioning, micro-controller interfacing, etc., leading to development of real-life IoT applications using latest technologies and various sensors & hardware/software tools.
Pre-Requisites	Knowledge of analog/digital electronics, micro-controller & computer programming, and transducer & measurement systems 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
	Design of DC Power Supply (Compulsory)
1	Design and analysis of a DC power supply circuit with +12V/1A, -12V/1A, +5V/1A, +9V/1A and variable outputs using SPICE simulation software.
2	Design of Printed Circuit Board (PCB) layout using Open Source software.
3	Fabrication of DC power supply circuit using chemical etching technique.
4	Component placing of the DC power supply circuit using proper soldering/de-soldering methodology.
5	Design and development of a signal conditioning circuit with the following specifications.
	Design of Microcontroller based System (Any One)
6	Design and development of a discrete state process control prototype using suitable sensors and microcontroller.
7	Design and development of a 4 digit display unit using 7-segment display and microcontroller for the given application.
8	Design and development of a stepper motor control driver circuit.
9	Design and development of a motion detector assembly using sensor and microcontroller.
10	Design and development of a temperature monitor and control system using microcontroller.
11	Design and development of AC Over-Under Voltage Protection circuit using microcontroller.
12	Design and development of alpha-numeric display using LCD and microcontroller.
13	Design and development of a real-time monitoring system using digital sensor, microcontroller and GSM modem.

Cont'd...

Experiment-#	Assignment/Experiment
	Project Work
14	Interfacing: (Microcontroller with full TCP/IP stack capability).
15	Embedded Linux: (Embedded Single Board Computer)

Text Books:

T1. J. P. Bentley, ***Principles of Measurement Systems***, 4th Edition, PHI, 2005.
T2. C. Pfister, ***Getting Started with the Internet of Things***, O'Reilly, 2011.
T3. J. Witts, ***Wearable-Tech Projects with the Raspberry Pi Zero***, O'Reilly, 2017.
T4. E. Hagan and J. Culkin, ***Learn Electronics with Arduino: An Illustrated Beginner's Guide to Physical Computing***, 1st Edition, O'Reilly, 2017.

Reference Books:

R1. R. Kamal, ***Internet of Things: Architecture and Design***, 1st Edition, McGraw Hill, 2017.
R2. R. A. Gayakwad, ***Op-Amps and Linear Integrated Circuits***, 4th Edition, Pearson Education, 2015.
R3. K.V. Rao, K. R. Sudha, and G M. Rao, ***Pulse & Digital Circuits***, Pearson Education, 2010.

Online Resources:

1. https://nptel.ac.in/courses/108105062/: by Prof. S. Sen and S. Mukhopadhyaya, IIT Kharagpur
2. https://nptel.ac.in/courses/106105166/: by Prof. S. Misra, IIT Kharagpur
3. https://nptel.ac.in/courses/106105159/: by Prof. A. Basu, IIT Kharagpur
4. https://nptel.ac.in/courses/108/105/108105064/: by Prof. A. Barua, IIT Kharagpur
5. http://www.eecg.toronto.edu/~kphang/teaching/spice/index.html
6. https://www.electronicshub.org/
7. https://www.elprocus.com/

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

CO1	Analyze the circuits using SPICE tools and implement on PCB using EDA tools.
CO2	Do proper soldering and effectively troubleshoot following the correct grounding & shielding methodologies.
CO3	Design and implement the signal conditioning and micro-controller interfacing circuits.
CO4	Apply the micro-controller programming to realize different applications.
CO5	Understand IoT with regards to its hardware & software components, interfacing of I/O devices, sensors & communication modules, and remote monitoring of data and control 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.

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.
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	3	2		3				1		3	2	3	1	1
CO2	1	1	3						2		2	1	2	1	1
CO3	2	2	3	1	1				1		2	1	3	2	1
CO4	2	2	3	2	1				1		2	1	2	2	2
CO5	1	2	2	1	3				2		2	1	3	3	3

Part IV

4th Year B. Tech. (EIE)

Curriculum Structure (Regular)

Semester VII									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
HS	BTBS-T-HS-022	Fundamentals of Management	3	0	0	3	0	0
PC	BTEC-T-PC-039	Communication Systems Engineering	3	0	0	3	0	0
PC	BTEI-T-PC-019	Industrial Automation & Control	3	0	0	3	0	0
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								
PC	BTEC-P-PC-040	Communication Systems Engineering Lab	0	0	2	0	0	1
PC	BTEI-P-PC-012	Industrial Automation and Control Lab	0	0	2	0	0	1
PJ	BTII-P-PJ-003	Summer Internship - III	0	0	0	0	0	1
		SUB-TOTAL	**15**	**0**	**4**	**18**	**0**	**3**
		TOTAL	**19**			**21**		

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	BTEI-P-PJ-015	Presentation Skills & Technical Seminar	0	0	4	0	0	2
PJ	BTEI-P-PJ-033	Project - II	0	0	16	0	0	8
VV	BTEI-P-VV-014	Comprehensive Viva	0	0	0	0	0	1
		SUB-TOTAL	**6**	**0**	**20**	**9**	**0**	**11**
		TOTAL	**26**			**20**		

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 215.*

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								
HS	BTBS-T-HS-022	Fundamentals of Management	3	0	0	3	0	0
PC	BTEC-T-PC-039	Communication Systems Engineering	3	0	0	3	0	0
PC	BTEI-T-PC-019	Industrial Automation & Control	3	0	0	3	0	0
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								
PC	BTEC-P-PC-040	Communication Systems Engineering Lab	0	0	2	0	0	1
PC	BTEI-P-PC-012	Industrial Automation & Control Lab	0	0	2	0	0	1
VV	BTEI-P-VV-014	Comprehensive Viva	0	0	0	0	0	1
		SUB-TOTAL	**15**	**0**	**4**	**18**	**0**	**3**
		TOTAL	**19**			**21**		

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 215.*

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									
HS	BTBS-T-HS-022	Fundamentals of Management	3	0	0	3	0	0
PC	BTEC-T-PC-039	Communication Systems Engineering	3	0	0	3	0	0
PC	BTEI-T-PC-019	Industrial Automation & Control	3	0	0	3	0	0
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								
PC	BTEC-P-PC-040	Communication Systems Engineering Lab	0	0	2	0	0	1
PC	BTEI-P-PC-012	Industrial Automation & Control Lab	0	0	2	0	0	1
PJ	BTII-P-PJ-003	Summer Internship - III	0	0	0	0	0	1
		SUB-TOTAL	**15**	**0**	**4**	**18**	**0**	**3**
		TOTAL	**19**			**21**		

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	BTEI-P-VV-014	Comprehensive Viva	0	0	0	0	0	1
		SUB-TOTAL	**0**	**0**	**0**	**3**	**0**	**17**
		TOTAL	**0**			**20**		

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 215.*

List of Electives

Code	Elective # and Subjects
Professional Elective - IV	
BTEC-T-PE-058	Advanced Electronic Circuits
BTEC-T-PE-052	Adaptive Signal Processing
BTEI-T-PE-022	Industrial Instrumentation
BTEI-T-PE-025	VLSI Design Verification & Testing
Professional Elective - V	
BTEI-T-PE-023	MEMS & Sensor Design
BTEC-T-PE-044	Digital Image & Video Processing
BTEE-T-PE-041	Advanced Control Systems
Professional Elective - VI	
BTEC-T-PE-054	Satellite Communication Systems
BTEC-T-PE-048	Mobile Communication & Networks
BTEI-T-PE-026	Industry 4.0
Open Elective - IV	
BTEE-T-OE-035	[EEE] Energy Studies
BTBS-T-OE-033	[BSH] Simulation & Modeling
BTBS-T-OE-034	[BSH] Entrepreneurship Development
BTEC-T-OE-053	[ECE] Mixed Signal Design
BTEC-T-OE-062	[ECE] Fiber Optic Communication
BTEC-T-OE-043	[ECE] Robotics & Robot Applications
BTEC-T-OE-049	[ECE] Embedded System Design
BTCS-T-OE-043	[CSE] Artificial Intelligence
BTCS-T-OE-044	[CSE] Introduction to Machine Learning

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

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	Communication Systems Engineering	L-T-P	Credits	Marks
PC	BTEC-T-PC-039		3-0-0	3	100

Objectives	The objective of this course is to study electronic communication systems, modulation techniques, digital transmission of analog signals, random variables, and sources & filtering of noise.
Pre-Requisites	Knowledge of signals & systems 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 Signal, Fourier Series, Fourier Transform, Properties of Fourier Transform, Orthogonal Signal.	**8 Hours**
Module-2	**Amplitude Modulation Systems**: Need for frequency translation, Double Side Band with Carrier (DSB-C), Double Side Band with Suppressed Carrier (DSB-SC), Modulators - Square-law, Switching, Balanced; Detectors: Square-law, Envelope, Synchronous; Single Side Band with Suppressed Carrier (SSB-SC), Frequency & Phase discrimination methods, Coherent detection, Modulation & demodulation of Vestigial Side Band modulation (VSB), Frequency Division Multiplexing, Radio Transmitter & Receiver (super heterodyne receiver).	**9 Hours**
Module-3	**Angle Modulation**: Angle Modulation, Narrow band FM, Wide band FM; FM Modulators: Direct method (Varactor diode method), Indirect method (Armstrong method), Simple slope detector, Balanced slope detector, Phase Locked Loop (PLL). **Analog Pulse Modulation**: Analog to Digital - The need, Sampling Theorem, Natural and Flat-top sampling, Quantization of signals, Quantization error, Pulse Amplitude Modulation, Pulse Width Modulation and Pulse Position Modulation.	**9 Hours**
Module-4	**Digital Pulse Modulation**: The PCM system, Bandwidth of PCM system, Delta Modulation (DM), Limitation of DM, Adaptive Delta Modulation, Differential PCM (DPCM), Comparison between PCM, DM, and DPCM. **Digital Transmission of Analog Signal**: Digital representation of analog signal, Line codes, Companding, Concept of Time Division Multiplexing, Multiplexing of PCM signals.	**8 Hours**
Module-5	**Random Variables and Processes**: Probability, Random variables, Useful probability density functions, Useful properties and certain application issues. **Mathematical Representation of Noise**: Sources of noise, Frequency-domain representation of noise, Superposition of noises, Linear filtering of noise, Noise bandwidth.	**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. J. G. Proakis and M. Salehi, ***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/117105143/: by Prof. G. Das, IIT Kharagpur
2. https://nptel.ac.in/courses/108/104/108104091/: by Prof. A. Jagannathan, IIT Kanpur
3. https://nptel.ac.in/courses/117/105/117105144/: by Prof. S. S. Das, IIT Kharagpur

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 fundamentals of amplitude modulation and demodulation techniques.
CO3	Articulate performance of angle modulation techniques and various analog pulse modulation schemes.
CO4	Explain different types of digital pulse modulation schemes and digital transmission of analog signals.
CO5	Visualize the behavior of random variables, noise signal in frequency domain, and linear filtering of noise.

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	3	3	2	2	2							1	2		1
CO2	3	3	3	2	2							1	3		1
CO3	3	3	2	2	2							1	3		1
CO4	3	3	3	2	2							1	3		1
CO5	3	3	2	2	2							1	2		1

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

Objectives	The objective of this course is to study the principles, operation, tuning, configuration and applications of process control elements including PLC and DCS for industrial uses and real time programming.
Pre-Requisites	Knowledge of basic electrical engineering and control system 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	**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.	**10 Hours**
Module-2	**Final Control Elements**: Pneumatic systems - Flapper nozzle system and its characteristics, I/P converter and pneumatic actuators; Electrical actuators – Solenoids, Motors, Principle of stepper motors, Elements of power electronic devices and driver circuits, Hydraulic actuators; Control valve – Types of control valve, Control valve sizing, Cavitation and flashing.	**8 Hours**
Module-3	**Special Control Structures**: Cascade control, Feed forward control, Feed forward-feedback control configuration, Ratio control, Selective control and adaptive control configuration.	**8 Hours**
Module-4	**Industrial Automation**: Programmable Logic Controllers – Introduction, Principles of operation, Architecture, Programming (Programming Languages, Ladder diagram, Boolean mnemonics); Distributed Control System – Distributed vs. Centralized, Advantages, Functional requirements, System architecture, Distributed Control Systems (DCS), Communication options in DCS.	**10 Hours**
Module-5	**Real-time Programming**: Multi-tasking, Task management, Inter-task communication, Real-time Operating System.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Bhanot, ***Process Control: Principles and Applications***, 1st Edition, Oxford University Press, 2008.
T2. K. Kant, ***Computer-Based Industrial Control***, 2nd Edition, PHI, 2009.
T3. C. D. Johnson, ***Process Control Instrumentation Technology***, 8th Edition, Pearson, 2014.
T4. D. R. Coughnowr, ***Process System Analysis and Control***, 3rd Edition, McGraw Hill, 2009.

Reference Books:

R1. J. Stenerson, ***Industrial Automation and Process Control***, 3rd Edition, Prentice Hall, 2003.

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 the process, characteristics, types of controllers, and PID controller tuning.
CO2	Identify the type of final control elements and explain its working principles.
CO3	Examine & troubleshoot the various controller structures and their configurations.
CO4	Apply the knowledge of PLC and DCS for automating industrial processes in real world.
CO5	Utilize the concepts of real-time programming to design industrial automation 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.
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	2	1	2	2	1						1	2		
CO2	2	1	1	1	1		1						1		
CO3	2	1	1		2								1		
CO4	2	2	1	2	3	1	1	1				1	3	1	1
CO5	2	1	1										1		

Type	Code	Advanced Electronic Circuits	L-T-P	Credits	Marks
PE	BTEC-T-PE-058		3-0-0	3	100

Objectives	The objective of this course is to study advanced electronic circuits such as various types of filters, multivibrator circuits, 555 timer, Schimitt trigger, sweep generators etc., and their applications in the real world.
Pre-Requisites	Fundamental knowledge of Basic Electronics and Analog 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	Active Filters: Active Filters and their frequency response; First order and Second Order Low-pass/High Pass Butterworth filter: Filter Design, Frequency Scaling, Band-pass and Band-reject filters (wide & narrow), All-Pass filter; Oscillators: Principles, Types, Quadrature and Voltage Controlled Oscillator, Saw tooth wave generator; Comparators: Basic comparator, zero-crossing detector, Schmitt Trigger, comparator characteristics, limitations of Op-Amp as comparators, voltage limiters.	**9 Hours**
Module-2	Bistable (Fixed Bias and Self Bias) Multivibrator, Loading, commutating capacitors, Triggering the binary (symmetrical and unsymmetrical through unilateral device), Schmitt Trigger Circuit (Emitter-coupled Bi-stable MV), Monostable Multivibrator (collector coupled and emitter coupled), Gate Width and Waveforms, Triggering of the Monostable MV, Astable Multivibrator (collector coupled and emitter coupled).	**9 Hours**
Module-3	Wide-band Amplifiers: The Hybrid-π, High-frequency, Small signal Common-emitter Model, RC-Coupled Amplifier, Frequency Response of a Transistor Stage, Short-Circuit Current Gain, Current Gain with Resistive Load, Transistor Amplifier Response taking Source Impedance into Account, Transient Response of a Transistor Stage; Negative Resistance Switching Devices: Voltage Controllable Negative resistance devices, Tunnel Diode operation and characteristics, Monostable, Astable, Bistable operations using tunnel diode, Voltage controlled Negative Resistance Switching circuits.	**8 Hours**
Module-4	Voltage and Current Time Base Generators: Time-Base Generators, General features of a Time-base signal, Methods of generating a voltage time-base waveform, Exponential sweep circuit, Miller and bootstrap time base generators - Basic principles, Transistor miller time-base generator, Transistor bootstrap time-base generator, Current time-base generators, A simple current sweep, Linearity correction through adjustment of driving waveform, Transistor current time-base generator.	**8 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	Specialized IC Applications: IC 555 Timer as Monostable and Astable Multivibrator, applications; Phase Locked Loop: Operating principle of PLL, Phase detectors, Exclusive-OR phase detector, Monolithic phase detector, Instrumentation Amplifier and its applications.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Millman and H. Toub, ***Pulse, Digital and Switching Waveforms***, 3rd Edition, McGraw Hill Education, 2017.
T2. R. A. Gayakwad, ***Op-Amps and Linear Integrated Circuits***, 4th Edition, Pearson Education, 2015.

Reference Books:

R1. A. A. Kumar, ***Pulse and Digital Circuits***, 2nd Edition, PHI Learning, 2008.
R2. K. V. Rao, K. R. Sudha, and G. M. Rao, ***Pulse and Digital Circuits***, 1st Edition, Pearson Education, 2011.

Online Resources:

1. https://nptel.ac.in/courses/108/102/108102095/: by Prof. S.C. Dutta Roy, IIT Delhi
2. https://nptel.ac.in/courses/117/107/117107094/: by Dr. P. Agarwal, IIT Roorkee
3. https://nptel.ac.in/courses/117108038/: by Prof. M. K. Gunasekaran, IISc Bangalore
4. https://www.elprocus.com/types-active-filters-and-applications/
5. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/108101091/lec69.pdf

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

CO1	Explain the concepts of active filters, oscillators, comparators and signal generators with their applications.
CO2	Describe & distinguish different multivibrators like astable, monostable and bistable multivibrators.
CO3	Design memory circuits, multivibrators, and microwave circuits using wide band amplifiers and negative resistance switching devices.
CO4	Design different types of voltage and current time-base generators for various engineering applications.
CO5	Use instrumentation amplifier in electronic communication circuits and realize specialized chip design for monostable and astable 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.

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	3	1	1							1	2	1	1
CO2	3	2	3	1	1							1	2	1	1
CO3	2	2	3	1									2		
CO4	3	2	2	1	1								2	1	
CO5	2	1			2								1	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	Industrial Instrumentation	L-T-P	Credits	Marks
PE	BTEI-T-PE-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 Telemetring, 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.
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.
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		
CO2	2	1	2	2	3		2						1		
CO3	2	2	2	2	2	1							1	1	2
CO4	2	3	2	2	1	2	1					1	1		
CO5	2	1	1	1	1	2	1	1					1	2	1

Type	Code	VLSI Design Verification & Testing	L-T-P	Credits	Marks
PE	BTEI-T-PE-025		3-0-0	3	100

Objectives	The objective of this course is to study analysis, verification and testing techniques of the design of digital VLSI circuits & systems.
Pre-Requisites	Knowledge digital electronic circuits, MOSFET, and digital VLSI design 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	**Fault Modeling**: Defects, Errors, and Faults, Functional Versus Structural Testing, Levels of Fault Models, Different Fault Models, Single Stuck-at Fault, Fault Equivalence, Equivalence of Single Stuck-at Faults, Fault Collapsing, Fault Dominance and Checkpoint Theorem.	**8 Hours**
Module-2	**Combinational Circuit Test Generation**: Algorithms and Representations, Structural vs. Functional Test, Definition of Automatic Test-Pattern Generator, Search Space Abstractions, Algorithm Completeness, ATPG Algebras, Algorithm Types, Redundancy Identification (RID), Testing as a Global Problem, Definitions, Significant Combinational ATPG Algorithms, D-Calculus and D-Algorithm (Roth), PODEM (Goel), FAN (Fujiwara and Shimino), Test Generation Systems	**9 Hours**
Module-3	**Sequential Circuit Test Generation**: ATPG for Single-Clock Synchronous Circuits, A Simplified Problem, Time-Frame Expansion Method, Use of Nine-Valued Logic, Development of Time-Frame Expansion Methods, Approximate Methods, Implementation of Time-Frame Expansion Methods, Complexity of Sequential ATPG, Cycle-Free Circuits, Cyclic Circuits, Clock Faults and Multiple-Clock Circuits, Asynchronous Circuits, Simulation-Based Sequential Circuit ATPG, CONTEST Algorithm.	**8 Hours**
Module-4	**IDDQ Test**: Motivation, Faults Detected by I_{DDQ} Tests, I_{DDQ} Testing Methods, I_{DDQ} Fault Coverage Metrics, I_{DDQ} Test Vector Selection from Stuck-Fault Vector Sets, Instrumentation Problems, Current Limit Setting, Surveys of I_{DDQ} Testing Effectiveness, Limitations of I_{DDQ} Testing, Delta I_{DDQ} Testing, I_{DDQ} Built-In Current Testing, I_{DDQ} Design for Testability.	**8 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	**Design for Testability**: Digital DFT and Scan Design – Ad-Hoc DFT Methods, Scan Design, Scan Design Rules, Tests for Scan Circuits; Built-in Self-Test – The Economic Case for BIST, Chip/Board Area Cost vs. Tester Cost, Chip/Board Area Cost vs. System Downtime Cost, Random Logic BIST Definitions, BIST Process, BIST Pattern Generation (Pseudo-Random Pattern Generation-LFSR), BIST Response Compaction (Transition Count Response Compaction, LFSR for Response Compaction, Modular LFSR Response Compaction), Built-in Logic Block Observers, Test-Per-Clock BIST Systems, Test-Per-Scan BIST Systems.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. M. L. Bushnell and V. D. Agarwal, ***Essentials of Electronic Testing for Digital, Memory and Mixed Signal VLSI Circuits***, Kluwer Academic Publishers, 2004.
T2. Z. Navabi, ***Digital System Test and Testable Design: Using HDL Model & Architecture***, Springer, 2010.

Reference Books:

R1. M. Abramovici, M.A. Breuer, and A.D. Friedman, ***Digital Systems and Testable Design***, 1st Edition, Jaico Publishing House, 2001.
R2. P. K. Lala, ***Digital Circuit Testing and Testability***, Academic Press, 2002.
R3. N. K Jha and S. G Gupta, ***Testing of Digital Systems***, Cambridge University Press, 2003.
R4. L. T. Wang, C. W. Wu, and X. Wen, ***VLSI Test Principles and Architectures***, Morgan Kaufmann Publishers, 2006.

Online Resources:

1. https://nptel.ac.in/courses/117105137
2. https://nptel.ac.in/courses/117103125
3. https://ocw.tudelft.nl/courses/vlsi-test-technology-reliabillity/
4. http://www.ee.ncu.edu.tw/~ares/course_VLSI_Testing.htm

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

CO1	Become familiar with different Fault Modeling of VLSI circuits and systems.
CO2	Design various testing technique of combinational VLSI circuits.
CO3	Design various testing technique of sequential VLSI circuits.
CO4	Analyze and design IDDQ testing method for different VLSI circuit.
CO5	Design for testability of different VLSI circuits using BIST and scan-based 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.

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.

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							3	1	1
CO2	2	3	3	3	3	1						1	2	2	1
CO3	2	2	3	2	2	1						1	2	2	1
CO4	3	3	3	3	2	2						1	1	3	2
CO5	3	3	3	2	3	1						1	1	3	1

Type	Code	MEMS & Sensor Design	L-T-P	Credits	Marks
PE	BTEI-T-PE-023		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	Properties of silicon: Crystal structure, Orientation effects, crystal defects, Impurities in Silicon, Properties of Silicon and Gallium Arsenide, Starting materials, Bridgeman techniques for crystal growth.	**6 Hours**
Module-2	Micromachining: Bulk Micromachining, Wet etching of silicon – Isotropic etching, Anisotropic etching, TMAH, EDP, Ultrasonic agitation, Quartz-vapour phase etches; Surface Micromachining – Thin film processes non-metallic thin film for micromachining, Wet etching, E-beam evaporation, Sputtering, Deposition by Epitaxy, CVD, PVD, E-plating; Electrodeposition Mechanism – DC electroplating, Pulsed electroplating, Electroless plating.	**10 Hours**
Module-3	Bonding Processes: Anodic Bonding, compound processes using bonding; Sacrificial Processes and Other Techniques – Sticking problem, Prevention, Sacrificial LIGA process; Advanced MEMS for Sensing and Actuation; Electromechanical Effects – Piezoresistance, Piezoelectricity, Shape memory alloy; Thermal effects – Temperature coefficient of resistance, Thermo-electricity, Thermocouples; Micro Fluidics Devices – Pumps, Valves, Mixers; Integrated fluidic systems – BioMEMS and applications.	**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; Case Study – Design Considerations of Piezoreistive Pressure Sensor.	**8 Hours**
Module-5	Design of Capacitive Accelerometer: Fundamentals of Quasi-Static Accelerometers, Position Measurement with Capacitance, Circuits for Capacitance Measurement & Demodulation Methods; Design Flow – Specifications, Sensor Design, Modelling, Fabrication and Packaging.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. G. K. Ananthasuresh, K. J. Vinoy, S. Gopalkrishnan, K. N. Bhat, and V. K. Aatre, ***Micro and Smart Systems***, 1st Edition, Wiley India, 2012.
T2. C. Liu, ***Foundations of MEMS***, Illionis ECE Series, Pearson Education, 2006.

T3. G. T. A. Kovacs, ***Micromachined Transducers Source Book***, McGraw-Hill Education, 1998.
T4. T. -R. Hsu, ***MEMS & Microsystems - Design and Manufacture***, 1st Edition, McGraw-Hill Education, 2017.

Reference Books:

R1. S. E. Lyshevski, ***Nano- and Micro-Electromechanical Systems : Fundamentals of Nano- and Microengineering (Vol. 8)***, CRC Press, 2005.
R2. S. D. Senturia, ***Microsystem Design***, Kluwer Academic Publishers, 2001.
R3. D. A. Bell, ***Electronic Instrumentation and Measurements***, 2nd Edition, Oxford University Press, 2007.
R4. S. K. Ghandhi, ***VLSI Fabrication Principles: Silicon and Gallium Arsenide***, 2nd Edition, Wiley, 2008.
R5. M. H. Bao, ***Micromechanical Transducers: Pressure Sensors, Accelerometers and Gyroscopes***, Elsevier, 2000.

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 process of micromachining and electrodeposition techniques.
CO3	Elaborate different micromachining bonding processes and the principles of advanced MEMS devices.
CO4	Analyze the steps of Microsystems design for different types of pressure sensors.
CO5	Design accelerometers and explain the steps of design considerations using a case study.

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	1	2	2	1								1	1		1
CO2	2	2	3	2								1	2		1
CO3	3	3	3	2								1	3		1
CO4	3	3	2	3								1	2		1
CO5	3	3	2	3								1	2		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 techniques – full search, fast search, Forward and backward motion prediction, Frames, Slices, Macro-blocks and blocks; 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	Advanced Control Systems	L-T-P	Credits	Marks
PE	BTEE-T-PE-041		3-0-0	3	100

Objectives	The objective of this course is to study the concepts of discrete-time & non-linear control systems, state-space analysis, design of compensators for control systems, and determine the performance using different measures.
Pre-Requisites	Basic knowledge on mathematics, digital signal processing and control system 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	Digital Control System: Sample and Hold, A/D and D/A conversion. Z-transform, Inverse Z-transform, Z-Transform method for solving difference equations, Impulse sampling & Data Hold, Sampling theorem, Folding, Aliasing, Pulse Transfer function, Mapping between s-plane and z-plane, Stability analysis of closed loop systems in the z-plane by use of Bilinear Transformation and Routh's stability criterion, Jury Stability.	**10 Hours**
Module-2	State Space Analysis: Concept of state and state variables, State model of linear systems, State Space representation using physical, phase, and canonical variables, Derivation of Transfer Function model from State Space Model; Diagonalization: Eigenvalues and Eigenvectors, Solution of State Equations, State Transition Matrix, Cayley-Hamilton Theorem, Controllability and Observability, Pole Placement by State Feedback, State Observer.	**8 Hours**
Module-3	Phase Plane Analysis: Common Physical Non Linearities - Saturation, Friction, Backlash, Relay and Multivariable Nonlinearity; Phase Plane Method: Basic Concepts, Singular Points, Nodal Point, Saddle Point, Focus Point, Vortex Point; Stability of Non Linear Systems: Limit Cycles, Construction of Phase Trajectories by Analytical Method and Graphical Methods.	**10 Hours**
Module-4	Describing Function Method: Basic Concepts, Derivation of Describing Functions; Stability Analysis by Describing Function Method: Stability Analysis by Gain-phase Plots, Jump Resonance, Introduction to Liapunov's Stability Criterion.	**6 Hours**
Module-5	Introduction to Design: Realization of compensators - Lag, Lead, and Lag-Lead compensator; Tuning of PID controller, Feedback compensation, Design of robust control system; Advances in control system: Introduction to optimal control, Performance measures like ISE, ITAE; Quadratic indices, Introduction to fuzzy control.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. K. Ogata, ***Discrete-Time Control System***, 2nd Edition, Pearson Education, 2015.
T2. I. J. Nagrath and M. Gopal, ***Control Systems Engineering***, 6th Edition, New Age International, 2017.

Reference Books:

R1. R. T. Stefani, B. Shahian, C. J. Savant, and G. H. Hostetter, ***Design of Feedback Control Systems***, 4th Edition, Oxford University Press, 2009.
R2. K. Ogata, ***Modern Control Engineering***, 5th Edition, Pearson Education, 2015.
R3. R. C. Dorf and R. H. Bishop, ***Modern Control Systems***, 12th Edition, Pearson Education, 2013.
R4. M. Gopal, ***Control Systems - Principles & Design***, 4th Edition, Tata McGraw Hill, 2012.
R5. N. S. Nise, ***Control Systems Engineering***, 5th Edition, Wiley India, 2008.

Online Resources:

1. https://www.nptel.ac.in/courses/108103008
2. http://www.nptelvideos.in/2012/11/advanced-control-system-design_27.html
3. http://web.mit.edu/2.14/www/Handouts/StateSpace.pdf
4. https://www.electrical4u.com/state-space-analysis-of--system
5. https://www.electrical4u.com/different-types-non-linearities-in-controlsystem

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

CO1	Implement Z-transform for solving difference equation in discrete time control system and check the system stability in Z-plane by various methods.
CO2	Articulate the concepts of state variables, state space representation in different forms and explain system controllability & observability.
CO3	Develop understanding of physical non-linearities and methods of stability analysis for non-linear systems.
CO4	Analyze the describing function and conduct stability analysis by various methods using advanced techniques.
CO5	Describe the design criteria of controller & compensator and perform stability analysis of the 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.

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								3	1	
CO2	3	3	2	3	1								3	2	1
CO3	3	3	3	2	3								3	1	
CO4	3	3	2	3	2								2	1	
CO5	3	3	3	3	1								3	2	1

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***, Willey, 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	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 prototols.
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	Industry 4.0	L-T-P	Credits	Marks
PE	BTEI-T-PE-026		3-0-0	3	100

Objectives	The objective of this course is to provide the concepts of Industry 4.0 transformations and implementation of Industrial Internet of Things (IIoT) in smart manufacturing, communication technologies, cyber-physical systems, and other emerging & smart manufacturing technologies.
Pre-Requisites	Knowledge on Internet technology, sensors, Internet of Things are 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	**Industry 4.0**: Introduction, Definition, The Value Chain, Industry 4.0 Design Principles: Interoperability, Virtualization, Decentralization, Real-Time Capability, Service Orientation, Modularity; Building Blocks of Industry 4.0, Smart Manufacturing, Smart Factory, Real-World Smart Factories.	**8 Hours**
Module-2	**Industrial IoT (IIoT)**: Introduction, Miniaturization, Wireless Technology, IP Mobility, Network Virtualization, The Cloud and Fog, Big Data and Analytics, Apache modules, M2M and Artificial Intelligence, AR & VR, 3D Printing and additive manufacturing.	**8 Hours**
Module-3	**IIoT Architecture**: IIC (Industrial Internet Committee), IIC Industrial Internet Reference Architecture, Industrial Internet Architecture Framework (IIAF): Introduction, Business viewpoint, usage and functional viewpoint; Architectural topology, Three-tier topology: Edge, Platform, Enterprise; key system characteristics, Data Management: Query, Storage, Persistence, Retrieval and Data Analytics.	**8 Hours**
Module-4	**Communication**: Proximity Network, WSN Edge Node, WSN Network Protocols, Low-Power Technologies, RS232, Live Zero (4-20ma) Current Loop, Field Bus Technologies, Modern Communication Protocols: Ethernet, Encapsulated Field Bus; Wireless Communication Technologies: IEEE 802.15.4, BLE, ZigBee, Z-Wave, Wi-Fi Backscatter, RFID, NFC, 6LoWPAN, RPL; Network Communication Protocols: IPv4, IPv6; Low-Power WAN Technologies: SigFox, LoRaWAN, nWave, Dash7, Ingénue RPMA, Low Power Wifi, LTE Category-M, Weightless, Millimeter Radio.	**10 Hours**
Module-5	**Advanced Concepts**: Cyber Physical Systems (CPS), Internet of Things and Services, Automatic Identification and Localization, M2M communications, Energy supply, Sensing and actuation, Data and Information processing, Human Machine Interaction, Artificial Intelligence, Advanced data analytics, Digital integration platform.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. A. Gilchrist, ***Industry 4.0: The Industrial Internet of Things***, 1st Edition, Apress, 2017.
T2. C. J. Bartodziej, ***The Concept Industry 4.0: An Empirical Analysis of Technologies and Applications in Production Logistics***, 1st Edition, Springer Gabler, 2016.

Reference Books:

R1. N. Jadhav, ***New-Age Technology and Industrial Revolution 4.0***, 1st Edition, Konark Publishers, 2019.
R2. K. Schwab, ***The Fourth Industrial Revolution***, Portfolio Penguin, 2017.
R3. G. V. A. Capasso, ***Hands-On Industrial Internet of Things***, Packt Publishers, 2018.

Online Resources:

1. https://nptel.ac.in/courses/106/105/106105195/: by Prof. S. Misra, IIT Kharagpur
2. https://www.youtube.com/watch?v=uXlPIXf2oTs/: by Dr. M. Egger, FH Upper Austria Research and Development GmbH
3. https://www.youtube.com/watch?v=VeSxcfdLp9I/: by R. Karamsetty, IoT Group, Intel

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

CO1	Describe the principles and concepts of smart manufacturing in modern industrial world.
CO2	Utilize Industrial Internet of Things to build smart industries.
CO3	Select and justify appropriate architecture for IIoT implementations.
CO4	Establish appropriate & efficient communication between IIoT enabled systems.
CO5	Explore the latest technological developments in IIoT applications for industry 4.0.

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	1	2									1	2		2
CO2	3	3	3	2								1	2	2	1
CO3	3	3	3	3								1	2	2	1
CO4	3	2	3	3								1	2	1	1
CO5	3	2	3	3								1	2	2	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-038		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	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	Mixed Signal Design	L-T-P	Credits	Marks
OE	BTEC-T-OE-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.

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	Fiber Optic Communications	L-T-P	Credits	Marks
OE	BTEC-T-OE-062		3-0-0	3	100

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	Bssic 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**

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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	Robotics & Robot Applications	L-T-P	Credits	Marks
OE	BTEC-T-OE-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	Embedded System Design	L-T-P	Credits	Marks
OE	BTEC-T-OE-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	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 (IDA), 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. Alpaydın, ***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, McGrow-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	Communication Systems Engineering Lab	L-T-P	Credits	Marks
PC	BTEC-P-PC-040		0-0-2	1	100

Objectives	The objective of this laboratory course is to get practical exposure to communication engineering by conducting experiments on spectrum analysis, FDM, TDM, PAM, PCM, FM & AM techniques using hardware & software.
Pre-Requisites	Basic knowledge of signals & systems, AM & FM modulation is required. Aquaintance with MATLAB and LabVIEW would be beneficial.
Teaching Scheme	Regular laboratory experiments conducted under supervision of the teacher. 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	To Plot and analyze the spectrum of following signals with aid of spectrum analyzer: Square wave, triangle wave and saw tooth wave.
2	Study and analyze various AM modulation and demodulation techniques.
3	Study of FM modulation and Demodulation Technique.
4	Study and Analyze the process of frequency division multiplexing and de-multiplexing.
5	Study and Analyze the Pulse Amplitude Modulation and de-modulation system.
6	Study and Analyze the Pulse code Modulation and de-modulation system.
7	Study and analysis of different AM techniques using MATLAB.
8	Study and analysis of FM technique using MATLAB.
9	Simulate AM modulation and demodulation system using LabView software.
10	Simulate FM modulation and demodulation system using LabView software.
11	To study and analyzeTime Division Multiplexing.
12	Study the functioning of Delta modulator and Adaptive Delta Modulator.

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. S. Haykin and M. Moher, ***Communication Systems***, 5th Edition, John Wiley & Sons, 2009.
R2. L. W. Couch II, ***Digital and Analog Communication Systems***, 8th Edition, Pearson Education, 2013.

Online Resources:

1. https://nptel.ac.in/courses/117/105/117105143/: by Prof. G. Das, IIT Kharagpur
2. https://nptel.ac.in/courses/108/104/108104091/: by Prof. A. Jagannathan, IIT Kanpur
3. https://nptel.ac.in/courses/117/105/117105144/: by Prof. S. S. Das, IIT Kharagpur

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

CO1	Analyze frequency spectrum of different type of wave forms.
CO2	Realize different analog modulation schemes and their effect in communications with the help of spectrum analyzer.
CO3	Understand multiple signal transmission using FDM and TDM schemes.
CO4	Realize the PAM and PCM systems.
CO5	Explain the functioning of Delta modulator and Adaptive Delta Modulator.

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.
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	3	2	2	2	2							1	2		1
CO2	3	3	2	2	3				1			1	3	1	1
CO3	3	3	2	2	3				1			1	3	1	1
CO4	3	2	2	2	2				1			1	2	1	1
CO5	3	2	2	2	2							1	2	1	1

Type	Code	Industrial Automation & Control Lab	L-T-P	Credits	Marks
PC	BTEI-P-PC-012		0-0-2	1	100

Objectives	The objective of this laboratory course is to get hands on exposure on applications of sensors, controller & final control elements for testing, calibration of measuring instruments, and various measuring techniques used in automation industry.
Pre-Requisites	Knowledge of sensors & transducers, control systems, instrumentation devices & systems is required.
Teaching Scheme	Regular laboratory experiments conducted under supervision of the teacher. Demonstration along with associated safety measures will be explained.

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	Performance analysis on ON-OFF/P/PI/PD/PID controllers of 1st and 2nd order processes.
2	Design of Feedback, Feed-forward and Cascade controller by MATLAB or SIMULINK.
3	PID Control Tuning by PRC, Ziegler-Nichols and Cohen-Coon techniques.
4	Measurement and study of the characteristics of P/I & I/P converter.
5	Experiments on air velocity sensor and its associated signal conditioner circuit.
6	Determination of the different types of valve characteristics & gain at various conditions.
7	Measurement of displacement by IR motion sensor.
8	Experiment on flow measurement by using flow sensor.
9	Measurement of position control by DC motor drives.
10	Experiments and study the characteristics of level control system.
11	Experiments and study the characteristics of Pressure control system.
12	Experiments on Phase-Plane analysis of Relay Control system.
13	Implementation of ladder logic programming for controlling various sequential processes.

Text Books:

T1. S. Bhanot, ***Process Control: Principles and Applications***, 1st Edition, Oxford University Press, 2010.
T2. M. Gopal, ***Digital Control and State Variable Methods***, 4th Edition, Tata McGraw-Hill, 2012.

Reference Books:

R1. J. Stenerson, ***Industrial Automation and Process Control***, 3rd Edition, Prentice Hall of India, 2003.
R2. C. D. Johnson, ***Process Control Instrumentation Technology***, 8th Edition, Pearson Education, 2014.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105064/: by Prof. A. Barua, IIT Khargpur

2. https://nptel.ac.in/courses/103106148/: by Prof. R. Rangaswamy, IIT Madras

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

CO1	Design & analyze of various processes and their time-response performance.
CO2	Investigate & design various controller structures and their configurations.
CO3	Design PID controller tuning methods and investigate the effect on industrial processes.
CO4	Analyze the performance of the associated measuring elements used in process industry.
CO5	Design, program, and implement PLC for various industrial automation 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.
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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	2	2	2	2					2				1	1	2
CO2	2	3	2	2					1				3	2	1
CO3	2	2	3	2					2				2	1	2
CO4	2	2	2	3					2				3	2	1
CO5	2	2	2	3					2				3	3	2

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