Silicon Institute of Technology
| An Autonomous Institute |

Curriculum Structure and Detailed Syllabus

Bachelor of Technology in Electrical & Electronics Engineering

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

Effective from Academic Year 2018-19
Build: 1.30 (31-08-2023)

Approval History

ACM#	Date	Resolutions
AC-1	14/08/2018	The curriculum & detailed syllabus of 1st Year, as proposed by the Board of Studies, is provisionally approved by the Academic Council.
AC-2	11/05/2019	The curriculum & detailed syllabus up to 2nd Year, as proposed by the Board of Studies, is approved by the Academic Council.
AC-3	28/09/2019	The amendments to the curriculum as suggested by the Boards of Studies, along with the proposal for provision of Practice School in the 4th year of B.Tech. is approved in principle by the Academic Council.
AC-4	18/08/2020	The curriculum & detailed syllabus up to 4th Year as suggested by the Boards of Studies, along with provision of Practice School in the 4th year 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 Educational Objectives (PEOs)

PEO1. ***Fundamental Knowledge & Core Competence***: To provide students with a foundation in mathematics, physics and core electrical and electronic areas required to formulate, solve and analyze engineering problems.

PEO2. ***Professional Skill & Society***: To analyze real life problems, apply the knowledge gained from modern design methodologies to address issues in a manner that is technically sound, economically feasible, and socially acceptable.

PEO3. ***Ethics & Life-long Learning***: To inculcate ethical attitude, effective communication skills, teamwork in their profession and adapt to current trends by engaging in lifelong learning needed for a successful professional career.

Program Specific Outcomes (PSOs)

PSO1. ***Engineering Knowledge & Analysis***: Apply engineering fundamental knowledge to identify, formulate, design and investigate complex engineering problems of electric circuits, power electronics, electrical machines and power systems and to succeed in competitive examinations.

PSO2. ***System Design & Professionalism***: Apply appropriate techniques and modern engineering hardware and software tools in power systems and power electronics to meet desired needs within realistic constraints such as economical, environmental, social, political, ethical, health and safety, manufacturability and sustainability.

PSO3. ***Leadership & Life-long Learning***: Function effectively as an individual or a leader in a team to manage different projects in multidisciplinary environment and appreciate the need for, and an ability to 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
CC	Compulsory Course
PJ	Summer Internship / Project Work / Seminar
PS	Practice School / Industry Internship
VV	Viva Voce

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	18BS1T01	Engineering Mathematics-I	3	0	0	3	0	0
BS	18BS1T05/ 18BS1T06	Engineering Chemistry/ Engineering Physics	3	0	0	3	0	0
ES	18ES1T01/ 18ES1T02	Basic Electronics Engineering/ Basic Electrical Engineering	2	0	0	2	0	0
ES	18ES1T03	Computer Programming	3	0	0	3	0	0
HS	18HS1T01	Communicative & Technical English	3	0	0	3	0	0
MC	18NC1T01/ 18NC1T02	Constitution of India/ Environmental Science & Engineering	2	0	0	0	0	0
PRACTICAL									
BS	18BS1L05/ 18BS1L02	Engineering Chemistry Lab/ Engineering Physics Lab	0	0	2	0	0	1
ES	18ES1L04/ 18ES1L05	Manufacturing Practices/ Engineering Graphics	0	0	2	0	0	1
ES	18ES1L01/ 18ES1L02	Basic Electronics Engineering Lab/ Basic Electrical Engineering Lab	0	0	2	0	0	1
ES	18ES1L03	Computer Programming Lab	0	0	4	0	0	2
HS	18HS1L01	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.

Semester II								
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
BS	18BS1T02	Engineering Mathematics-II	3	0	0	3	0	0
BS	18BS1T06/ 18BS1T05	Engineering Physics/ Engineering Chemistry	3	0	0	3	0	0
ES	18ES1T02/ 18ES1T01	Basic Electrical Engineering/ Basic Electronics Engineering	2	0	0	2	0	0
ES	18ES1T05	Data Structures & Algorithms	3	0	0	3	0	0
MC	18NC1T02/ 18NC1T01	Environmental Science & Engineering/ Constitution of India	2	0	0	0	0	0
PRACTICAL								
BS	18BS1L02/ 18BS1L05	Engineering Physics Lab/ Engineering Chemistry Lab	0	0	2	0	0	1
ES	18ES1L05/ 18ES1L04	Engineering Graphics/ Manufacturing Practices	0	0	2	0	0	1
ES	18ES1L02/ 18ES1L01	Basic Electrical Engineering Lab/ Basic Electronics Engineering Lab	0	0	2	0	0	1
ES	18ES1L06	Data Structures & Algorithms 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.

Type	Code	Engineering Mathematics - I	L-T-P	Credits	Marks
BS	18BS1T01		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 & Curve Tracing	**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, vector space	**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 and applying those to curve tracing.
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								2	1	1
CO3	3	3	3	3	1								2	1	1
CO4	3	3	3	2	3								2	1	1
CO5	3	3	2	2	2								2	1	1

Type	Code	Engineering Chemistry	L-T-P	Credits	Marks
BS	18BS1T05		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 contents have been conceived in taking into account appropriate combinations of old and new emerging concepts in the chemical sciences area and their current and potential uses in 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.	**6 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	**Industrial Lubricants**: Lubricants-Concept of tribology; Types of lubricants and Mechanism of lubrication, Physical and Chemical properties of lubricants, Additives of lubricants, Selection of lubricants, Flash Point, cloud point, freezing points of lubricants.	**5 Hours**
Module-4	**Instrumental Techniques**: Fundamentals of Spectroscopy; Principles and applications of molecular spectroscopy (such as UV-visible, IR and microwave).	**6 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	**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**
Module-6	**Nanochemistry**: 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.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. Jain & Jain, ***Engineering Chemistry***, 16th Edition, Dhanpat Rai Publishing Company, 2015.
T2. G. A. Ozin & A. C Arsenault, ***Nanochemistry - A Chemical Approach to Nanomaterials***, RSC Publishing.
T3. C. N. Banwell, ***Fundamentals of Molecular Spectroscopy***, 3rd Edition, McGraw Hill.

Reference Books:

R1. S. S. Dara, ***Engineering Chemistry***, 12th Edition, S. Chand Publisher, 2014.
R2. Wiley-India Editorial Team, ***Engineering Chemistry***, 2nd Edition, Wiley India.
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://www.analyticalinstruments.in/home/index.html
5. www.edx.org/
6. https://www.ntnu.edu/studies/courses
7. http://www.corrosionsource.com/
8. http://nptel.ac.in/courses/105104102/hardness.htm
9. http://nptel.ac.in/courses/105106112/1_introduction/5_corrosion.pdf
10. 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	Understand the characteristics of industrial lubricants, mechanism of lubrication and study kinematic viscosity & flash point of lubricating oil for application in engineering.

Cont'd...

CO4	Understand the concept of molecular spectroscopy and analyze organic compounds using spectrophotometer.
CO5	Classify various fuels based on combustion parameters and understand the working principle of various batteries.
CO6	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.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

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

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

Type	Code	Engineering Physics	L-T-P	Credits	Marks
BS	18BS1T06		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	1	2
CO2	3	2	1	2	1							1	3	1	1
CO3	3	2		1								1	2	1	2
CO4	3	2		1								1	3		1
CO5	3	3	1	2	1							1	3	1	2

Type	Code	Basic Electronics Engineering	L-T-P	Credits	Marks
ES	18ES1T01		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, Amplifiers, Digital logic inverters. (2 Hours) **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. Opto-Electronic Devices – LEDs, Photo Diodes and Applications (8 Hours)	**10 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.	**5 Hours**
Module-3	**Field Effect Transistor (FET)**: Construction, Characteristics of Junction FET (JFET), Depletion and Enhancement type Metal Oxide Semiconductor FETs (MOSFET), Fixed and Voltage divider Biasing Configurations, 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.	**4 Hours**
Module-5	**Feedback Amplifiers**: Principle, Advantages of Negative Feedback, Different Feedback Topologies. **Oscillators**: Classification, RC Phase Shift Oscillator, High Frequency LC Oscillator.	**4 Hours**
	Total	**28 Hours**

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. 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***, 3rd Edition, S. Chand Publishing, 1980.

Online Resources:

1. http://www.electrical4u.com/circuit-analysis.htm
2. http://www.allaboutcircuits.com
3. https://www.electronics-tutorials.ws/
4. https://www.edx.org/course/circuits-electronics-1-basic-circuit-mitx-6-002-1x-0

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

Type	Code	Basic Electrical Engineering	L-T-P	Credits	Marks
ES	18ES1T02		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. Transient Analysis: Writing differential equations for circuits, Time-domain analysis of first-order RL and RC circuits.	**8 Hours**
Module-2	Representation of sinusoidal wave forms, Peak and RMS values, Phasor representation, Real, Reactive, and Apparent power, Power factor. Analysis of single-phase AC circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel). Three phase balanced circuits, Voltage and current relations in star and delta connections.	**6 Hours**
Module-3	Electricity and magnetism, Magnetic circuit and magnetic reluctance, Magnetic materials, BH characteristics, Ideal and practical transformer, EMF equation of transformer, Equivalent circuit.	**4 Hours**
Module-4	Construction of DC machines, Generator, Types of excitation system, Working of DC motor, Classification of DC motor, Characteristics and speed control of DC motor. Generation of rotating magnetic fields, Construction and working of a 3-phase induction motor, Torque-slip characteristic. Single-phase induction motor.	**4 Hours**
Module-5	Introduction to Measuring instruments: Different electrical measuring instruments, Energy meters: Connection and elementary calculations for energy consumption. Brief introduction to generation, transmission and distribution of electrical power, Earthing & electrical safety.	**3 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://www.slideshare.net/billylui/lecture-1-fundamental-of-electricity
2. https://www.tutorialspoint.com/gate_syllabus/gate_electrical
3. https://www.tutorialspoint.com/theory_of_machines
4. https://www.smartzworld.com/notes/electrical-measurements-em
5. https://lecturenotes.in/subject/113/electrical-power-transmission
6. https://nptel.ac.in/courses/108108076/
7. 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 DC source.
CO2	Measure current, voltage and power of series RLC circuit excited by single-phase AC circuit.
CO3	Develop understanding of different concepts of magnetic fields and apply it to single phase transformer.
CO4	Study the working principles of rotating electrical machines.
CO5	Become familiar with the components of low-voltage electrical installations and different measuring instruments.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
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.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the 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	3	3	1	2									3	1	
CO2	3	3	2	3									3	1	
CO3	3	2	1	1				2					3		
CO4	3	2	2										3		
CO5	3	3	2	1									3	1	

Type	Code	Computer Programming	L-T-P	Credits	Marks
ES	18ES1T03		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
CO2	3	3	2	2								1	3		2
CO3	3	3	2	2								1	3		2
CO4	3	2	2	2								1	3		2
CO5	3	3	2	3								1	2		2

Type	Code	Communicative & Technical English	L-T-P	Credits	Marks
HS	18HS1T01		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		3	3
CO2									1	3	1	3		3	1
CO3								1	3	3	2	3		3	2
CO4										3		3		1	2
CO5								2	1	3	1	3		3	2

Type	Code	Constitution of India	L-T-P	Credits	Marks
MC	18NC1T01		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
CO2						2	1	1	1					1	2
CO3						3	1	1	1					1	1
CO4						2	1	1	1					1	2
CO5						2	1	2	1					1	2

Type	Code	Environmental Science & Engineering	L-T-P	Credits	Marks
MC	18NC1T02		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.	**5 Hours**
Module-2	Environmental gradients & Laws: Environmental gradients, tolerance levels of environment factors, Indian environmental laws and activities including seminar presentations by students.	**4 Hours**
Module-3	Water & Wastewater Treatment: Water quality standards and parameters, pre-treatment and conventional treatment processes of water, DO, BOD, COD, wastewater treatment.	**4 Hours**
Module-4	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-5	Solid Waste & Hazardous Waste Management: Source, classification and composition of MSW, MSW management, 3R principles, hazardous waste generation and their management, environment impact assessment, origin & procedure of EIA, project screening for EIA, scope studies, preparation and review of EIS.	**5 Hours**
Module-6	Environment and Human Health: Environment and human health, the impact of the IT industry on the environment including e-waste, activities including presentation & report submission on environmental problems.	**5 Hours**
	Total	**28 Hours**

Text Books:

T1. G. M. Masters and W. P. Ela, ***An Introduction to Environmental Engineering and Science***, PHI.
T2. G. Kiely, ***Environmental Engineering***, Intl. Edition, McGraw Hill.

Reference Books:

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

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	Understand environmental gradients, tolerance levels and environmental laws for prevention of environmental pollution.
CO3	Enhance knowledge of water and wastewater treatment for prevention of water pollution.
CO4	Understand the chemistry of pollutants in the atmosphere, soil and groundwater and understand principles of noise abatement.
CO5	Enhance knowledge of waste minimization technique to minimize and manage solid, hazardous wastes generated in different areas.
CO6	Understand the role of IT and human health, and the issues of e-waste management.

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

Type	Code	Engineering Mathematics - II	L-T-P	Credits	Marks
BS	18BS1T02		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, Hyper geometric, 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, difference of two means, variance.	**7 Hours**
Module-6	Testing of Hypothesis about mean, two means and 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	1	1
CO2	3	3	3	3	3								3	1	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	18ES1T05		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. http://nptel.ac.in/courses/106102064/1
2. http://www.nptelvideos.in/2012/11/programming-and-data-structure.html
3. https://www.tutorialspoint.com/data_structures_algorithms/index.htm
4. https://www.coursera.org/learn/data-structures/
5. 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.

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

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

Type	Code	Engineering Chemistry Lab	L-T-P	Credits	Marks
BS	18BS1L05		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
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.
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.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

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

Type	Code	Engineering Physics Lab	L-T-P	Credits	Marks
BS	18BS1L02		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	1	1
CO2	2	2		1	1							1	2		1
CO3	2	1		2									2	1	1
CO4	2	2		3	1								3		1
CO5	3	1		1								1	2		1

Type	Code	Manufacturing Practices	L-T-P	Credits	Marks
ES	18ES1L04		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.

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

Type	Code	Engineering Graphics Lab	L-T-P	Credits	Marks
ES	18ES1L05		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.

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	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	1		1

Type	Code	Basic Electronics Engineering Lab	L-T-P	Credits	Marks
ES	18ES1L01		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		
CO2	3	3	2	1									3		
CO3	2	2	2	1									2		
CO4	2	2	3										2		

Type	Code	Basic Electrical Engineering Lab	L-T-P	Credits	Marks
ES	18ES1L02		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, help the students 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	Make electrical connections by wires 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
CO2	2			2		1		2	1	1	2	1	1		1
CO3	1			3		2		2	1	1	1	1	1		1
CO4	1			2		2		1	1	2	2	1	1		1
CO5	1			1		1		1	1	1	1	1	1		1

Type	Code	Computer Programming Lab	L-T-P	Credits	Marks
ES	18ES1L03		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
CO2	3	3	3	2								1	3		2
CO3	3	3	3	2								1	3		2
CO4	3	2	2	2								1	2		1
CO5	3	3	2	3								1	2		2

Type	Code	Communicative & Technical English Lab	L-T-P	Credits	Marks
HS	18HS1L01		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		3	3
CO2								1	3	3	2	3		2	2
CO3										3		3		2	2
CO4								2	3	3	2	3		3	3
CO5								1	1	3		3		2	3

Type	Code	Data Structures & Algorithms Lab	L-T-P	Credits	Marks
ES	18ES1L06		0-0-4	2	100

Objectives	Develop skills to design and analyze simple linear and non linear data structures. It strengthen the ability of students to identify and apply the suitable data structure for the given real world problem. It enables them to gain knowledge in practical applications of data structures.
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	Single linked list operations.
13	Single linked list operations (continued).
14	Double linked list operations.
15	Double linked list operations (continued).
16	Circular linked list operations.
17	Stack using linked list.
18	Queue using linked list.
19	Polynomial addition using linked-list.
20	BST operations.
21	BST operations (continued).
22, 23	Graph traversal (BFS, DFS).
24	Warshall's shortest path algorithm.
25	Insertion Sort, quick sort.

Cont'd...

Experiment-#	Assignment/Experiment
26	Merge Sort.
27, 28	Implementation of 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. http://nptel.ac.in/courses/106102064/1
2. http://www.nptelvideos.in/2012/11/programming-and-data-structure.html
3. https://www.tutorialspoint.com/data_structures_algorithms/index.htm
4. https://www.coursera.org/learn/data-structures/
5. https://www.geeksforgeeks.org/data-structures/

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

Part II

2nd Year B. Tech. (EEE)

Curriculum Structure

Semester III									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
BS	18BS1T03	Math-III for ECE/EEE/EIE	3	0	0	3	0	0
ES	18ES1T04	Engineering Mechanics	3	0	0	3	0	0
ES	18ES1T06	OOP Using Java	3	0	0	3	0	0
PC	18EE1T01	Circuit Theory	3	0	0	3	0	0
PC	18EI1T01	Analog Electronic Circuits	3	0	0	3	0	0
PC	18EE1T02	Measurements & Instrumentation	3	0	0	3	0	0
PRACTICAL									
ES	18ES1L07	OOP Using Java Lab	0	0	2	0	0	1
PC	18EE1L01	Circuit Theory Lab	0	0	2	0	0	1
PC	18EI1L01	Analog Electronic Circuits Lab	0	0	2	0	0	1
PC	18EE1L02	Measurments & Instrumentation Lab	0	0	2	0	0	1
PJ	18IR6L01	Summer Internship - I	0	0	0	0	0	1
		SUB-TOTAL	**18**	**0**	**8**	**18**	**0**	**5**
		TOTAL	**26**			**23**		

Semester IV									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
BS	18BS1T04	Math-IV for ECE/EEE/EIE	3	0	0	3	0	0
PC	18EE1T03	Control Systems Engineering	3	0	0	3	0	0
PC	18EC1T03	Digital Electronic Circuits	3	0	0	3	0	0
PC	18EE1T04	Electrical Machines - I	3	0	0	3	0	0
HS	18HS1T02	Engineering Economics	3	0	0	3	0	0
MC	18NC1T03	Professional Ethics & Values	2	0	0	0	0	0
PRACTICAL									
PC	18EE1L03	Control Systems Engineering Lab	0	0	2	0	0	1
PC	18EC1L01	Digital Electronic Circuits Lab	0	0	2	0	0	1
PC	18EE1L04	Electrical Machines - I Lab	0	0	4	0	0	2
MC	18NC7L01	Yoga	0	0	2	0	0	0
		SUB-TOTAL	**17**	**0**	**10**	**15**	**0**	**4**
		TOTAL	**27**			**19**		

Type	Code	Math-III for ECE/EEE/EIE	L-T-P	Credits	Marks
BS	18BS1T03		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	Engineering Mechanics	L-T-P	Credits	Marks
ES	18ES1T04		3-0-0	3	100

Objectives	The objective of this course is to provide an introductory treatment of Mechanical Engineering with working knowledge of statics, force equilibrium & free body diagrams, and behavior of a body/particle in a dynamic condition.
Pre-Requisites	Basic analytical and logical understanding including basic knowledge of Physic and 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	**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, basic concept of pulleys, basic concepts of vector approach method.	**8 Hours**
Module-2	**Friction, Virtual Work, and Energy Method**: 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, Virtual displacements, principle of virtual work for particle and ideal system of rigid bodies, degrees of freedom.	**8 Hours**
Module-3	**Center of Gravity & Moments of Inertia**: Centroid and Centre of Gravity, Centroid of simple figures from first principle, centroid of composite sections, Centre of Gravity and its implications, Theorems of Pappus and Guldinus, Area moment of inertia - Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard & composite sections, Mass moment inertia of Circular Plate, Cylinder, Cone, Sphere, Parallelepiped.	**8 Hours**
Module-4	**Analysis of Structures**: Trusses, Assumptions, rigid and non-rigid trusses, Simple Plane truss, analysis by method of joints and method of sections; Distributed forces in a plane: Beam, types of loading and supports, Shear Force and Bending Moment diagram, relation among load-shear force-bending moment.	**8 Hours**
Module-5	**Kinematics of Rectilinear & Curvilinear Motion**: Differential equations of rectilinear motion, Force proportional to displacement, Free vibration, D'Alembert's Principle, Momentum and Impulse, Work & Energy, Conservation of energy, Impact; Normal and Tangential acceleration, Motion of a Projectile, Work and Energy in curvilinear motion; Kinematics of rotation, Rotation under the action of a constant moment.	**10 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Timoshenko, D. H. Young, S. Pati, and J. V. Rao, ***Engineering Mechanics***, 5th Edition, Tata McGraw-Hill, 2013.

Reference Books:

R1. J. L. Meriam and L. G. Kraige, ***Engineering Mechanics: Statics*** & ***Engineering Mechanics: Dynamics*** (two books), 7th Edition, John Wiley & Sons. 2012.
R2. S. S. Bhavikatti, ***Engineering Mechanics***, 3rd Edition, New Age International, 2008.
R3. E. W. Nelson, C. L. Best, W. G. McLean, and M. Potter, ***Schaum's Outline of Engineering Mechanics - Statics*** & ***Dynamics*** (two books), 5th Edition, McGraw-Hill, 2010.

Online Resources:

1. https://nptel.ac.in/courses/112103108/
2. https://swayam.gov.in/courses/5241-engineering-mechanics

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

CO1	Understand and analyze the principles of mechanics to solve problems in statics.
CO2	Understand the concepts of friction and Virtual work and apply it to solving the problems.
CO3	Apply the concepts of centroid, Center of gravity, area moment of inertia and mass moment of inertia and apply them for basic structural design.
CO4	Investigate the nature of forces in the members of simple trusses and understand the concepts Distributed forces in a plane.
CO5	Analyze and solve the problems in dynamics for both rectilinear and curvilinear motion.

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

Type	Code	OOP Using Java	L-T-P	Credits	Marks
ES	18ES1T06		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, Unified Modeling Language, UML class diagram, Use-case diagram; Java Overview: Java Virtual Machine, Java buzz words, Data types, Operators, Control statements, Class fundamentals, Objects, Methods, Constructors, Overloading, Access modifiers.	**9 Hours**
Module-2	Inheritance: Basics of Inheritance, using super and final keyword, method overriding, Abstract classes, defining and importing packages, access protection, interfaces; Exception handling: Exception fundamentals, types, understanding different keywords (try, catch, finally, throw, throws), User defined exception handling.	**8 Hours**
Module-3	Input/Output: Files, stream classes, reading console input; Threads: thread model, use of Thread class and Runnable interface, thread synchronization, multithreading, inter thread communication.	**8 Hours**
Module-4	String manipulation: Basics of String handling, String class, StringBuilder, StringBuffer, StringTokenizer. Applet basics and life cycle; Event Handling: delegation event model, event classes, sources, listeners, Adapter class.	**8 Hours**
Module-5	Introduction to GUI Programming: working with windows, frames, graphics, color, and font. AWT Control fundamentals. Swing overview; JavaFX overview; Java database connectivity: JDBC overview, creating and executing queries, dynamic queries.	**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. 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 principles in software design process to develop Java programs for real life applications.
CO2	Employ inheritance and exception handling techniques for developing robust and reusable software.
CO3	Develop programs using stream classes for various I/O operations and design concurrent programs using threads to maximize the use of processing power.
CO4	Design applications for text processing using String class and develop user interactive applications using event handling.
CO5	Design database driven GUI applications using AWT, Swing and JDBC.

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	1	2	2		1						2	3		3
CO4	3	2	3	1		1						2	3		3
CO5	3	2	3	1		1						2	3		3

Type	Code	Circuit Theory	L-T-P	Credits	Marks
PC	18EE1T01		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	Laplace Transform & its Application: Introduction, Laplace transform of some basic functions, Laplace transform of periodic functions, Inverse Laplace transform, initial and final value theorem; Application Of Laplace Transform for Transient Analysis: Response of RL, RC & RLC network with step, sinusoidal, impulse and ramp input.	**8 Hours**
Module-3	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 behavior from Pole-Zero plots.	**6 Hours**
Module-4	Fourier Series & its Application: Fourier series, Fourier analysis and evaluation of coefficients, Steady state response of network to periodic signals; Fourier Transform: Fourier transform of some basic functions, Properties of Fourier Transform; Application of Fourier transform to electrical network; Filter: Introduction, Types and classification of Filter, introduction to design parameters of passive filter, Design of active filters and their frequency response.	**12 Hours**

Cont'd...

Module-#	Topics	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.	**8 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. A Chakrabarti, ***Circuit Theory: Analysis and Synthesis***, 7th Edition, Dhanpat Rai & Co., 2013.

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.

Online Resources:

1. https://nptel.ac.in/courses/108102042/
2. https://nptel.ac.in/courses/108106075/
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	Apply concepts of network theorems and coupled circuits in solving complex networks problems and frequency response and analysis of different resonant circuits.
CO2	Understand the switching phenomena of electrical circuits and evaluate transient and steady state performance using Laplace Transformation.
CO3	Determine two-port network parameters and their practical application to electrical and electronic circuits.
CO4	Analyze sinusoidal & non-sinusoidal signals using Fourier series and transform, identify & design various filters and examine their frequency response.
CO5	Identify Network Functions and synthesize one port network using Foster and Cauer forms.

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	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	18EI1T01		3-0-0	3	100

Objectives	The objective of this course is to be familiar with Transistors (BJT, JFET and MOSFET) amplifiers, differential amplifiers and their implementations, and also study their characteristics and 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)**: Construction and V-I Characteristics of BJT, Operation (CB, CE and CC Configurations), relation between the current gain, BJT Biasing, Bias Stability, Design of different Biasing Techniques, Operating point.	**9 Hours**
Module-2	**Field Effect Transistor (FET)**: Construction, V-I Characteristics of Junction FET (JFET), JFET Biasing (Fixed, Self and Voltage divider); MOSFET Circuits: Construction, Characteristics of Depletion and Enhancement type Metal Oxide Semiconductor Field Effect Transistor (MOSFETs), MOSFET as a switch, MOSFET as an amplifier, Introduction to CMOS circuits.	**9 Hours**
Module-3	**AC Analysis of Amplifies**: BJT small signal model, Transistor re model and Hybrid Model of CB, CE and CC configuration, Effect of R_L and R_S, Darlington pair; JFET small signal model, Fixed bias, Self bias, voltage divider bias, common gate, source follower, effect of R_L and R_S, Current Mirror, Cascade & Cascode configuration; Frequency Response of BJT and FET, Miller Effect Capacitance, Multistage Frequency Effects.	**10 Hours**
Module-4	**Operational Amplifiers**: Differential amplifier, CMRR, Ideal op-amp and its characteristics; Inverting and non-inverting amplifier, integrator, differentiator, differential amplifier, instrumentation amplifier, active filter.	**7 Hours**
Module-5	**Feedback Amplifiers**: Concepts of feedback, General characteristics of negative feedback amplifiers, Topology, simple problems on practical negative feedback amplifiers, Condition for oscillations; RC-phase shift, Wien-bridge and Crystal oscillators.	**7 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	Understand and analyze the structural configuration, different biasing methods of BJT.
CO2	Analyze the structural behavior, characteristics and different biasing configurations of JFET and MOSFET.
CO3	Design small signal models and estimate the performance parameters of different amplifier configurations required for the industry.
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.
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								2		
CO2	3	3	3	3	2								2		
CO3	3	3	2	3	2								3		
CO4	3	3	3	2	3							1	3		1
CO5	3	3	3	3	3							1	3		1

Type	Code	Measurements & Instrumentation	L-T-P	Credits	Marks
PC	18EE1T02		3-0-0	3	100

Objectives	The objective of this course is to introduce the students to basic principle of operation of different electrical & electronic measuring instruments and their uses in different branches of engineering. The course will also introduce the 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	Types of Measurement Systems, Accuracy and Precision, Types of Errors, Standards and calibration, Classification of Measuring instruments. **Electromechanical Indicating type Instruments**: Types of torque, general constructional details. **Ammeter and Voltmeter**: Derivation for Deflecting Torque of PMMC, MI, Electro Dynamometer and Induction type. **Measurement of Power, Energy and Frequency**: Construction, Theory and Principle of operation of (a) Electro-Dynamometer and Induction type Wattmeter (b) Single Phase Induction Type Watt-hour meter (c) Frequency Meter.	**10 Hours**
Module-2	**Measurement of Resistance**: Measurement of Resistance of Insulating Materials, Measurement of Resistance of Earth Connections. **Measurement of Inductance**: Maxwell's, Hay's, Anderson Bridge, Measurement of Mutual-Inductance by Felici's method. **Measurement of Capacitance**: Wein's, Owen's and Schering Bridge. Wagnor's earthling device.	**8 Hours**
Module-3	**Potentiometer**: DC Potentiometers (Crompton), AC Potentiometers (Drysdale-Tinsley). **Instrument Transformers**: Construction, Theory, Equivalent circuit, Phasor Diagram, and characteristics of CTs and PTs.	**8 Hours**
Module-4	**Electronic Instruments**: Digital voltmeters, Ammeters, Multimeters, AC Voltmeters using Rectifiers. **Storage and Display Devices**: Magnetic disk and tape recorders, Digital plotters and printers, CRT display, Digital CRO, LED, LCD & dot matrix display, Data loggers.	**8 Hours**
Module-5	**Transducers and Data Acquisition Systems**: Classification of transducers, Selection of transducers, Resistive, Capacitive & Inductive transducers, Piezoelectric, Hall effect, Optical and digital transducers, Elements of data acquisition system, A/D and D/A converters, Smart sensors.	**8 Hours**
	Total	**42 Hours**

P.T.O

Text Books:

T1. E. W. Golding and F. C. Widdis, ***Electrical Measurements and Measuring Instruments***, 5th Edition, Reem Publication, 2015.
T2. A. K. Sawhney, ***A Course in Electrical and Electronics Measurement and Instrumentation***, 19th Edition, 2011.
T3. R. K. Rajput, ***Electrical and Electronic Measurement and Instrumentation***, S. Chand & Co, 2016.

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***, S. K. Kataria & Sons, 2013..

Online Resources:

1. https://www.youtube.com/watch?v=11cWFio3h4U
2. https://nptel.ac.in/syllabus/108106070/
3. http://www.npl.co.uk/upload/pdf/beginners-guide-to-measurement-in-electronic-and-electrical-engineering.pdf
4. http://lrf.fe.uni-lj.si/fkkt_ev/Literatura/Electrical_and_Electronics_Measurment.pdf

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

CO1	Identify the instrument suitable for accurate and precise measurement of current, voltage, power and energy with their construction, theory and operating principle.
CO2	Estimate accurately the values of R, L and C employing suitable bridges.
CO3	Understand the construction, theory and working of Potentiometers and Instrument Transformers and their application.
CO4	Learn the working principle of various electronics instruments, storage and display devices.
CO5	Understand the working of various transducers and data acquisition 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.

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

Type	Code	OOP Using Java Lab	L-T-P	Credits	Marks
ES	18ES1L07		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.
11	Applet life cycle implementation, text processing using Java predefined String, StringBuilder and StringBuffer classes.
12	GUI basics and Window fundamentals, working with different Component, Container and Layout Managers.
13	Event handling for interactive GUI application.
14	Java database connectivity using JDBC, steps and use of different drive types.

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 principles in software design process and develop Java programs for real-life applications.
CO2	Employ inheritance and exception handling techniques for developing robust, reusable software.
CO3	Develop programs using stream classes for various I/O operations and design concurrent programs using threads to maximize the use of processing power.
CO4	Design applications for text processing using String class and develop user interactive applications using event handling.
CO5	Design database driven GUI applications using AWT, Swing and JDBC.

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	1	2	2		1						2	3		3
CO4	3	2	3	1		1						2	3		3
CO5	3	2	3	1		1						2	3		3

Type	Code	Circuit Theory Lab	L-T-P	Credits	Marks
PC	18EE1L01		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	Study of DC and AC Transients.
3	Determination of circuit parameters: Open Circuit and Short Circuit parameters.
4	Determination of circuit parameters: Hybrid and Transmission parameters.
5	Frequency response of Low pass and High Pass Filters.
6	Frequency response of Band pass and Band Elimination Filters.
7	Determination of self inductance, mutual inductance and coupling coefficient of a single phase two winding transformer representing a coupled circuit.
8	Study of resonance in R-L-C series circuit.
9	Study of resonance in R-L-C parallel circuit.
10	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. A Chakrabarti, ***Circuit Theory: Analysis and Synthesis***, 7th Edition, Dhanpat Rai & Co., 2013.

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.

Online Resources:

1. https://nptel.ac.in/courses/108102042/
2. https://nptel.ac.in/courses/108106075/
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 of different configurations in electrical networks.
CO4	Employ concept of coupled circuits to electrical machines.
CO5	Analyze sinusoidal & non-sinusoidal signals using Fourier series and transform.
CO6	Identify & design various filters 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	1	2	1							1	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	18EI1L01		0-0-2	1	100

Objectives	The objective of the course is to design, implement and testing of 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 JEET/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 amplifiers circuits: DC bias and AC operation without and with 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	2	1	1
CO2	3	3	2	3	2								2	1	
CO3	3	3	2	3	3								2	1	
CO4	3	3	3	3	3								2	1	
CO5	3	2	2	3	2							1	2	1	1
CO6	3	2	3	3	3								2	1	

Type	Code	Measurements & Instrumentation Lab	L-T-P	Credits	Marks
PC	18EE1L02		0-0-2	1	100

Objectives	The objective of the course is to cover the constructional features, working principle, testing, and calibration of different measuring instruments and provide an overview of various measuring techniques.
Pre-Requisites	Basic knowledge of different electrical components and different analysis techniques of electrical and magnetic circuits. Topics taught in EEM theory class are essential 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	Measurement of Low Resistance using Kelvin's Double Bridge.
2	Measurement of Self Inductance using Anderson's Bridge.
3	Measurement of capacitance using Schering Bridge.
4	Calibration of Voltmeters and Ammeters using Crompton's Potentiometer.
5	Testing of Energy meters (Single phase type).
6	Study of hysteresis loop using CRO.
7	Measurement of R, L, and C using Q-meter.
8	Measurement of Power in a single phase circuit using CT and PT.
9	Measurement of Power and Power Factor in a three phase AC circuit by two-wattmeter method.
10	Study of Lissajous pattern using CRO and measurement of unknown frequency.
11	Measurement of Iron Loss from B-H Curve by using CRO.
12	Measurement of Self-Inductance using Ammeter-Voltmeter method.
13	Study of Spectrum Analyzer.

Text Books:

T1. E. W. Golding and F. C. Widdis, ***Electrical Measurements and Measuring Instruments***, 5th Edition, Reem Publication (Selected portions from Ch. V, VI, VII, VIII, IX, XVII, XVIII), 2015.
T2. A. K. Sawhney, ***A Course in Electrical and Electronics Measurement and Instrumentation***, 19th Edition (Selected portions from Chapter 2, 3, 10, 11, 12, 13, 15, 20, 22, 23, 24, 33), 2011.
T3. R. K. Rajput, ***Electrical and Electronic Measurement and Instrumentation***, S Chand & Co, 2016.

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 (Selected portions from Ch. 1, 3, 6, 7, 9, 10, and 13), 2015.

Online Resources:

1. https://www.youtube.com/watch?v=11cWFio3h4U
2. https://nptel.ac.in/syllabus/108106070/
3. http://www.npl.co.uk/upload/pdf/beginners-guide-to-measurement-in-electronic-and-electrical-engineering.pdf
4. http://lrf.fe.uni-lj.si/fkkt_ev/Literatura/Electrical_and_Electronics_Measurment.pdf

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

CO1	Estimate accurately the values of R, L and C employing suitable bridges.
CO2	Measure power and energy with suitable measuring instruments.
CO3	Learn about different types of electronic instruments.
CO4	Calibrate different measuring instruments.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
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.
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	1	1	1					1				1		
CO2	2	1	2	2					1				1	1	
CO3	2	2	2	2					1				2		
CO4	1	1	1						1				1		1

Type	Code	Math-IV for ECE/EEE/EIE	L-T-P	Credits	Marks
BS	18BS1T04		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	Control Systems Engineering	L-T-P	Credits	Marks
PC	18EE1T03		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**: Basic Concepts, Open loop and Closed loop systems, Servo Mechanism/Tracking System; Mathematical Models of Physical Systems: Differential Equations of Physical Systems, Transfer functions, Block Diagram Algebra, Signal flow Graphs; **Feedback Characteristics**: Reduction of parameter variation, Control over System Dynamics, Control of the effects of disturbance signals, linearizing effect, regenerative feedback.	**8 Hours**
Module-2	**Time Response Analysis**: Standard Test Signals, Time response of first & second order systems, type & order of a system, Steady State Errors and Static Error Constants, Effect of adding pole and zero to a system, Design specification of second order system, Performance indices; **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, Rout Contours, Systems with transportation lag.	**12 Hours**
Module-3	**Frequency Response Analysis**: Correlation between Time and Frequency Response, Polar plots, Bode plots, All Pass and Minimum- Phase Systems; **Stability in Frequency Domain**: Mathematical Preliminaries, Nyquist Stability Criterion, Assessment of Relative stability using Nyquist Criterion, Closed loop Frequency Response, Sensitivity Analysis in Frequency Domain.	**10 Hours**
Module-4	**State Variable Analysis**: Introduction, Concepts of State, State Variables and State Model, Solution of State Equations, Concepts of Controllability and Observability; **Introduction to Controllers**: Proportional Derivative 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).	**9 Hours**
Module-5	**Control System Components**: Modeling of Stepper motor, AC & DC Servo motor, Synchros, AC Tachometer.	**3 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. S. H. Saeed, ***Automatic Control Systems***, 6th Edition, S. K. Kataria & Sons, 2008.
R2. B. S. Manke, ***Linear Control Systems with MATLAB Applications***, Khanna Publications, 1986.
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	Understand and apply basic concepts of control system to develop mathematical model of various physical systems in engineering and also study effect of feedback on system characteristics.
CO2	Use standard test signals to determine performance characteristics of first and second-order systems and determine the stability using time domain techniques.
CO3	Identify the methods of frequency domain analysis and apply it to determine different types of stability in frequency domain.
CO4	Differentiate between Transfer Function and State-Space approach of describing a system and understand the design of conventional controllers used in industry.
CO5	Understand different types of control components and its design for reliable and efficient application in 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.
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...

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

Type	Code	Digital Electronic Circuits	L-T-P	Credits	Marks
PC	18EC1T03		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 program 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	Electrical Machines - I	L-T-P	Credits	Marks
PC	18EE1T04		3-0-0	3	100

Objectives	The objective of this course is to introduce the students to different electrical machines. The course will cover the constructional features, working principles and various aspects of DC & AC machines and its applications.
Pre-Requisites	Knowledge of Basic Electrical Engineering, Physics and knowledge of Basic Mathematics such as Calculus, 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	**DC Machines**: General principles, Constructional features, Armature Windings (Simplex Lap and Simplex Wave), Expression for EMF Induced and Torque developed in the Armature counter Torque and Counter or Back EMF, Methods of Excitation, Armature Reaction. **DC Generator**: Conditions for Self Excitation, Critical Resistance and Critical Speed. Internal and External Characteristics for self and Separately Excited DC Generator.	**8 Hours**
Module-2	**DC Motor**: Characteristic for Speed $\sim$ Armature Current, Torque $\sim$ Armature Current and Speed $\sim$ Torque of a DC Shunt, Series and Compound Motor and Comparison. **Performance of DC Machine**: DC Motor Starting, Necessity of a Starter, Starting of DC Shunt, Series and Compound Motors, Grading of starter resistance, Speed Control of DC Shunt and Series motor, Losses, efficiency and power flow diagram in a DC Machine, Braking.	**7 Hours**
Module-3	**Single Phase Transformers**: Basic construction; Phasor Diagrams at No-Load and Load Conditions of an Ideal transformer and practical transformer, Equivalent Circuit, Determination of Parameters from Tests (Polarity Test, Open Circuit Test and Short Circuit Test, Back to Back test), Per Unit Calculation and its importance, Voltage Regulation, Losses, Efficiency and All Day efficiency; Parallel operation of transformers and load sharing. **Auto Transformer**: Basic constructional features; VA conducted magnetically and electrically. Comparative study with two winding transformer; Conversion of a two winding transformer into a single winding transformer.	**13 Hours**

Cont'd...

Module-#	Topics	Hours
Module-4	**Three Phase Transformers**: Constructional features, As a single unit and as a bank of three single phase transformers; Three-Phase Transformer connections, The per unit system for Three Phase Transformer, Transformer Ratings and Related problems, Two Single-Phase Transformers connected in Open Delta (V-Connection) and their rating; T-Connection (Scott Connection) of Two Single-Phase Transformers; Transformer Three phase Connections: Various Phase Displacements (0°, 180°, +30°and -30°), Connection Diagrams and Phasor Diagrams of various Vector Groups (Yy0, Dd0, Dz0, Yy6, Dd6, Dz6, Yd1, Dy1, Yz1, Yd11, Dy11, and Yz11), 3-winding transformers and its equivalent circuit.	**8 Hours**
Module-5	Components of a practical transformer,power and distribution transformer, all day efficiency, cooling of transformers, Buchholtz's relay, Tap changing transformers and its application. Overcurrent and overvoltage transients, Inrush current in single phase and three phase transformers, Switching of loaded transformer.	**6 Hours**
	Total	**43 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, 2017.

Reference Books:

R1. P. S. Bimbhra, ***Electrical Machinery***, 7th Edition, Khanna Publishers, 2011.
R2. A. E. Clayton and N. N. Hancock, ***The Performance and Design of DC Machines***, 3rd Edition, CBS Publishers, 2006.
R3. D. P. Kothari and I. J. Nagrath, ***Electric Machines***, 5th Edition, McGraw-Hill Education, 2017.
R4. P. K. Mukherjee and S. Chakravorti, ***Electrical Machines***, Dhanpat Rai Publications, 2011.
R5. B. S. Guru and H. R. Hiziroglu, ***Electric Machinery and Transformers***, 3rd Edition, Oxford University Press, 2012.

Online Resources:

1. https://nptel.ac.in/courses/108105017/
2. https://nptel.ac.in/courses/108106072/
3. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-685-electric-machines-fall-2013/

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

CO1	Understand the concept of constructional features and operating principle of DC machines and Analyze the different performance characteristics of DC generator.
CO2	Apply the different speed control, starting, braking methods of DC motor and determine different performance parameters like losses, efficiency.
CO3	Understand the operating principle of single-phase transformer and autotransformer and determine the equivalent circuit parameters and efficiency using various tests of single-phase transformer.
CO4	Learn about the constructional and operational features of three phase transformer and different connections like open delta and Scott connections and its application.
CO5	Acquire the necessary knowledge about the practical transformer and analyze different transient phenomenon in transformers.

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

Type	Code	Engineering Economics	L-T-P	Credits	Marks
HS	18HS1T02		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	Professional Ethics & Values	L-T-P	Credits	Marks
MC	18NC1T03		2-0-0	0	100

Objectives	To enable the students to create an awareness on professional ethics and human values, to instill moral and social values & loyalty to appreciate the rights of others, and to provide the basis for deciding that 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 Ethics: Basic terms – Moral, Values, Ethics, Personal and Professional Ethics, Ethical Dilemma, Resolving Ethical Dilemma, Emotional Intelligence, Moral Development Theories of Kohlberg and Piaget, Views on Ethics by Aristotle, Governing factors of an individual's value system.	**6 Hours**
Module-2	Profession and Professionalism: Profession, Professional, Professionalism, Professional Accountability, Professional Risks, Conflict of interest, Ethical Theories and their application – Consequentialism, Deontology, Virtue theory, Rights Theory, Casuist theory, Moral Absolutism, Moral Relativism, Moral Pluralism.	**9 Hours**
Module-3	Ethics in Engineering: Engineering as a profession, Engineers as Managers, Constultants, and Leaders, Engineering as social experimentation, Issues in engineering ethics.	**3 Hours**
Module-4	Engineers' Responsibility and Safety: Safety and Risk (underestimating, over estimating, indifference), Risk-benefit analysis, Engineers' Responsibility for Safety.	**3 Hours**
Module-5	Global Ethical Issues: Different ethical issues in Business, Corporate Social Responsibility, Environment, IT, Bioethics, Intellectual Property Rights, Research, and Media.	**7 Hours**
	Total	**28 Hours**

Text Books:

T1. R. Subramanian, ***Professional Ethics***, 2nd Edition, Oxford University Press, 2017.

Reference Books:

R1. M. W. Martin and R. Schinzinger, ***Ethics in Engineering***, Tata McGraw Hill, 2013.
R2. C. E. Harris, M. S. Pritchard, and M. J. Rabins, ***Engineering Ethics - Concepts and Cases***, Thompson Learning, 2003.
R3. D. Albuquerque, ***Business Ethics***, Oxford University Press, 2013.
R4. E. G. Seebauer and R. L. Barry, ***Fundamentals of Ethics***, Oxford University Press, 2012.

R5. R. S. Naagarazan, ***A Text Book on Professional Ethics and Human Values***, 2nd Edition, New Age International, 2016.

Online Resources:

1. https://india.oup.com/orcs/9780199475070/

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.

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

Type	Code	Digital Electronic Circuits Lab	L-T-P	Credits	Marks
PC	18EC1L01		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	Electrical Machines - I Lab	L-T-P	Credits	Marks
PC	18EE1L04		0-0-4	2	100

Objectives	The objective of the course is to introduce different electrical machines and help understand & verify basic concepts of electrical machines, calculate different parameters like voltage regulation, efficiency & losses and their effect on performance. The laboratory experiments shall go hand-in-hand with the topics taught in the theory class.
Pre-Requisites	Knowledge of Basic Electrical Engineering, Physics and knowledge of Basic Mathematics such as Calculus, ordinary differential equations is required.
Teaching Scheme	Regular laboratory experiments to be conducted under supervision of the faculty with demonstration and simulation-based verification for the experiments to be conducted.

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
	Hardware based Experiments
1	Determination of Efficiency and Voltage Regulation by Open Circuit and Short Circuit test on single phase transformer.
2	Parallel operation of two single phase transformers
3	Back-to Back test on two single phase transformers.
4	Performance of grid connected induction generator.
5	Determination of critical resistance and critical speed from no load test of a DC shunt generator
6	Plotting of external and internal characteristics of a DC shunt generator.
7	Speed control of DC shunt motor by armature voltage control and flux control method.
8	Determination of efficiency of a shunt motor by brake test.
9	Determination of efficiency of a shunt machine by Swinburne's test.
10	Various vector group of three phase transformer
11	Determination of efficiency and voltage regulation of a single phase transformer by direct loading.
12	Study of open delta and Scott connection of two single phase transformers.
	Software based Experiments
13	Brake Test on a DC Shunt Motor: To obtain the performance characteristics of a DC shunt motor by load test.
14	Swinburne's Test: To pre-determine the efficiency of a D.C shunt machine considering it as a motor by performing Swinburne's test on it.
15	Separation of Losses in a D.C. Shunt Motor: To obtain separately the hysteresis, eddy current and windage losses of the given motor.

Cont'd...

Experiment-#	Assignment/Experiment
16	Open Circuit Characteristics of a D.C. Shunt Generator: To find the critical resistance (Rc) and critical speed (Nc) and O.C.C. of a dc shunt generator
17	Speed Control of a D.C Shunt Motor : To obtain the speed characteristics of a D.C shunt motor as a function of armature voltage, field current, and external resistance in the armature circuit.

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, 2017.

Reference Books:

R1. P. S. Bimbhra, ***Electrical Machinery***, 7th Edition, Khanna Publishers, 2011.
R2. A. E. Clayton and N. N. Hancock, ***The Performance and Design of DC Machines***, 3rd Edition, CBS, 2006.
R3. D. P. Kothari and I. J. Nagrath, ***Electric Machines***, 5th Edition, McGraw-Hill Education, 2017.
R4. P. K. Mukherjee and S. Chakravorti, ***Electrical Machines***, Dhanpat Rai Publications, 2011.
R5. B. S. Guru and H. R. Hiziroglu, ***Electric Machinery and Transformers***, 3rd Edition, Oxford University Press,, 2012.

Online Resources:

1. https://nptel.ac.in/courses/108105017/
2. https://nptel.ac.in/courses/108106072/
3. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-685-electric-machines-fall-2013/

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

CO1	Determine different characteristics of DC generator and calculate voltage regulation.
CO2	Analyze the load and no-load characteristics of DC motor and draw different characteristics DC Motor.
CO3	Understand the different speed control, starting and braking methods of DC motor and perform different tests on DC machines.
CO4	Determine the equivalent circuit parameters of single-phase transformer and efficiency using various tests and understand the parallel operation of transformers.
CO5	Verify different speed control, testing and starting methods of D.C motor and obtain characteristics of D.C machines using MATLAB Simulation.

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

Type	Code	Control Systems Engineering Lab	L-T-P	Credits	Marks
PC	18EE1L03		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	Study the interrelationship between Transfer function and State Space model of a system using simulation & programming.
8	Plot the root locus of a given transfer function using simulation & 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.
T3. B. S. Manke, ***Linear Control Systems with MATLAB Applications***, Khanna Publications, 1986.

Reference Books:

R1. R. Pratap, ***Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers***, South Asia Edition, Oxford University Press, 2010.
R2. S. H. Saeed, ***Automatic Control Systems***, 6th Edition, S. K. Kataria & Sons, 2008.
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									2		
CO2	2	3	2	1	2								2		
CO3	2	2	1	1									2		
CO4	3	3	1	1	2	1						1	2	2	1
CO5	2	1		1	2								1	2	

Type	Code	Yoga	L-T-P	Credits	Marks
MC	18NC7L01		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; introduction of Yoga
2	*Pranayama*; performing breathing exercise
3	*Mudra*; learning various types of *Mudra*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 Visrant Asana Samuha*; eye movement and exercises
7	Twisting set; standing twisting asana
8	Side stretching set; standing Side stretching *asana*
9	Forward bending set; standing Forward bending *asana*
10	Backward bending set; standing Backward bending *asana*
11	Balancing set; learning *Vrikshasana*, *Ekpada Pranamasana* and benefits
12	*Surya Namaskar*; surya namaskar mantra and poses
13	*Vajrasana* set; sitting *asana* sets
14	*Padmasana* set; sitting *asana* sets
15	Sleeping asana and *Yoga Nidra*; 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

Part III

3rd Year B. Tech. (EEE)

Curriculum Structure

Semester V								
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
PC	18EE1T05	Power Electronics	3	0	0	3	0	0
PC	18EE1T06	Electromagnetic Theory	3	0	0	3	0	0
PC	18EE1T07	Electrical Machines - II	3	0	0	3	0	0
ES	18ES1T09	Engineering Thermodynamics	3	0	0	3	0	0
PE	18**2T**	Professional Elective - I	3	0	0	3	0	0
OE	18**3T**	Open Elective - I	3	0	0	3	0	0
PRACTICAL								
PC	18EE1L05	Power Electronics Lab	0	0	2	0	0	1
PC	18EE1L07	Electrical Machines - II Lab	0	0	4	0	0	2
HS	18HS1L02	Soft Skills & Inter-Personal Skills Lab	0	0	4	0	0	2
PJ	18IR6L02	Summer Internship - II	0	0	0	0	0	1
		SUB-TOTAL	**18**	**0**	**10**	**18**	**0**	**6**
		TOTAL	**28**			**24**		

Semester VI								
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
PC	18EE1T08	Electrical Power Transmission & Distribution	3	0	0	3	0	0
PC	18EC1T09	Introduction to Digital Signal Processing	3	0	0	3	0	0
PC	18EC1T10	Fundamentals of Microprocessors & Microcontrollers	3	0	0	3	0	0
PE	18**2T**	Professional Elective - II	3	0	0	3	0	0
PE	18**2T**	Professional Elective - III	3	0	0	3	0	0
OE	18**3T**	Open Elective - II	3	0	0	3	0	0
PRACTICAL								
PC	18EC1L09	Introduction to Digital Signal Processing Lab	0	0	2	0	0	1
PC	18EC1L10	Fundamentals of Microprocessors & Microcontrollers Lab	0	0	2	0	0	1
PC	18EE1L08	Electrical Power Transmission & Distribution Lab	0	0	2	0	0	1
PJ	18EE6L03	Skill Lab & Project - I	0	0	4	0	0	2
		SUB-TOTAL	**18**	**0**	**10**	**18**	**0**	**5**
		TOTAL	**28**			**23**		

Note: *Courses offered under each elective are given in "List of Electives" on Page 105.*

List of Electives

Code	Elective # and Subjects
	Professional Elective - I
18EC2T01	Advanced Electronic Circuits
18EI2T02	Transducers & Measurement Systems
18EE2T03	Electrical Engineering Materials
18EE2T04	Renewable Energy Systems
18EC2T05	Signals & Systems
	Professional Elective - II
18EE2T06	Advanced Power Electronics
18EE2T07	Advanced Control Systems
18EE2T08	Electrical Drives
	Professional Elective - III
18EI2T09	IoT & Applications
18EC2T10	Analog Communication
18EE2T11	HVDC Transmission
	Open Elective - I
18BS3T01	[BSH] Applied Linear Algebra
18BS3T02	[BSH] Fluid Mechanics
18EC3T03	[ECE] Electronic Devices & Modeling
18CS3T04	[CSE] Fundamentals of DBMS
18EI3T05	[EIE] Biomedical Instrumentation & Signal Processing
	Open Elective - II
18BS3T06	[BSH] Numerical Optimization
18BS3T07	[BSH] Organizational Behaviour
18EC3T08	[ECE] Adaptive Signal Processing
18CS3T09	[CSE] Operating Systems
18CS3T10	[CSE] Programming in Python
18EI3T11	[EIE] Industrial Automation & Control

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

Type	Code	Power Electronics	L-T-P	Credits	Marks
PC	18EE1T05		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.	**6 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	Electromagnetic Theory	L-T-P	Credits	Marks
PC	18EE1T06		3-0-0	3	100

Objectives	The objective of this course is to study, analyze, synthesize & interpret the application of electric & magnetic fields as functions of time & space using different coordinate systems, and propagation of electromagnetic waves.
Pre-Requisites	Knowledge of physics, mathematics, and fundamentals of engineering sciences 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	Vector Analysis: Scalars, Vectors, Unit vector, Scalar & Vector fields, Co-ordinate systems and transformation, Cartesian co-ordinates, Cylindrical co-ordinates, Spherical co-ordinates and Application; Vector Calculus: Line, Surface and volume integrals, Del operator, Gradient of a scalar, Divergence of a vector and Divergence theorem, Curl of a vector and Stoke's theorem, Laplacian and Applications.	**8 Hours**
Module-2	Electrostatic Fields: Coulomb's Law, Electric field intensity, Electric fields due to point, line, surface and volume charge, Electric flux density, Gauss's Law - Maxwell's equation, Application of Gauss's Law, Electric potential, Potential due to a line, Surface and volume charge; Conservative field, Relationship between E & V - Maxwell's equations, An Electric Dipole, Dipole moment, Expression of E due to an electric Dipole, Energy density in the Electrostatic fields; Conductors: Current and Current density, Continuity equation, Point form of Ohm's law, Resistance of a conductor, Relaxation time; Dielectrics: Polarization, Dielectric strength, Capacitance, Boundary conditions, Poisson's and Laplace's equation, Uniqueness Theorem, General procedures for solving Laplace's equation.	**12 Hours**
Module-3	Magnetostatic Fields: Magnetic field Intensity, Biot-Savart's law & its application, Ampere's Circuital Law & its application, Magnetic scalar & vector potentials, Magnetic Boundary conditions, Application; Force in Magnetic Fields: Force on a moving Point charge, Force between two straight, Long and parallel conductors carrying currents.	**8 Hours**
Module-4	Faraday's Law and Lenz's Law: Statically inducted EMF, Dynamically induced EMF, Displacement current density and displacement current, Physical significance of displacement current; Maxwell's Equations for Static fields, Maxwell's equations for Time varying fields: Maxwell's Equation for Harmonic varying fields; Maxwell's Equation for Good conductors, Maxwell's Equation for Free space; Retarded Potential, Average power density, Poynting vector and Poynting Theorem(Integral & Point forms),Applications.	**8 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	Wave Propagation: Electromagnetic wave, Electromagnetic wave equation in phasor form, Intrinsic impedance, The loss tangent, Uniform plane waves, Uniform plane wave in lossy dielectric, Perfect dielectric, Free space and in Good conductors, Skin depth, Transmission lines, Transmission line equations, Characteristic impedance, Wave form distortion, Distortionless line.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. S. C. Mahapatra and S. Mahapatra, ***Principles of Electromagnetics***, 2nd Edition, McGraw Hill Education, 2015.
T2. M. N. O. Sadiku and S. V. Kulkarni, ***Principles of Electromagnetic***, 6th Edition, Oxford University Press, 2009.

Reference Books:

R1. E. C. Jordan and K. G. Balmin, ***Electromagnetic Waves and Radiating Systems***, 2nd Edition, Pearson Education, 2009.
R2. B. N. Basu, ***Engineering Electromagnetic Essential***, 1st Edition, Orient Blackswan, 2015.

Online Resources:

1. https://nptel.ac.in/courses/115/101/115101005/: Prof. D. K. Ghosh, IIT Bombay
2. https://nptel.ac.in/courses/108/104/108104087/: by Prof. P. Kumar, IIT Kanpur
3. https://nptel.ac.in/courses/108/102/108102119/: by Prof. S. Aditya, IIT Delhi
4. https://nptel.ac.in/courses/115/104/115104088/: by Prof. M. K. Harbola, IIT Kanpur
5. https://nptel.ac.in/courses/108/106/108106073/: by Prof. H. Ramachandran, IIT Madras

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

CO1	Explain various co-ordinate systems and solve problems involving vector calculus.
CO2	Describe electrostatic fields, their characteristics and associated parameters.
CO3	Visualize magneto-static fields, their characteristics and associated parameters.
CO4	Analyze and apply Maxwell's equations to various electromagnetic fields.
CO5	Interpret the propagation of EM waves through different mediums.

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

Type	Code	Electrical Machines - II	L-T-P	Credits	Marks
PC	18EE1T07		3-0-0	3	100

Objectives	The objective of this course is to introduce the principle of operation, construction and performance of synchronous machines and induction machines. The course will cover starting and speed control of induction machines and performance of different special machines.
Pre-Requisites	Knowledge of Basic Electrical Engineering, Physics and knowledge of Basic Mathematics such as Calculus, 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	**Synchronous Generator**: Constructional details, Types of rotors, Brush less excitation, Winding factors, Emf equation, Synchronous reactance, Armature reaction, Phasor diagrams of non-salient pole synchronous generator connected to infinite bus, Synchronizing and parallel operation, Synchronizing torque, Change of excitation and mechanical input, Voltage regulation – EMF, MMF and ZPF methods, Steady state power-angle characteristics, Two reaction theory, Phasor diagram for salient pole machines, Reluctance power and power angle characteristics, Slip test.	**12 Hours**
Module-2	**Synchronous Motor**: Principle of operation, Torque equation, Operation on infinite bus bars, V and Inverted V curves, Power input and power developed equations, Starting methods, Current loci for constant power input, Constant excitation and constant power developed, Hunting, Natural frequency of oscillations, Damper windings, Synchronous condenser.	**6 Hours**
Module-3	**Three Phase Induction Motor**: Constructional details, Types of rotors, Principle of operation, Slip, Cogging and crawling, Equivalent circuit, Torque-Slip characteristics, Condition for maximum torque, Losses and efficiency, Load test, No load and blocked rotor tests, Circle diagram, Separation of losses, Double cage induction motors, Induction generators, Synchronous induction motor.	**9 Hours**
Module-4	**Starting and Speed Control Of Three Phase Induction Motor**: Need for starter, Types of starters, DOL, Rotor resistance, Autotransformer and Star-delta starters; Speed Control: Voltage control, Frequency control and pole changing, Cascaded connection, V/f control, Slip power recovery scheme; Braking of three phase Induction motor: Plugging, dynamic braking and regenerative braking.	**6 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	**Single Phase Induction Motors and Special Machines**: Constructional details, Double field revolving theory and operation, Equivalent circuit, No load and blocked rotor test, Performance analysis, Starting methods of single-phase induction motors, Capacitor Start, Capacitor run Induction motor, Shaded pole induction motor, Linear induction motor, Repulsion motor, Hysteresis motor, AC series motor, Servo motors, Stepper motors, Switched reluctance motor, BLDC motor, Introduction to magnetic levitation systems.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. A. E. Fitzgerald, C. Kingsley Jr., and S. D. Umans, ***Electric Machinery***, 6th Edition, McGraw-Hill, 2017.

T2. S. J. Chapman, ***Electric Machinery and Fundamentals***, 4th Edition, McGraw-Hill, 2017.

Reference Books:

R1. P. S. Bimbhra, ***Electrical Machines***, 2nd Edition, Khanna Publishers, 2017.

R2. D. P. Kothari and I. J. Nagrath, ***Electrical Machines***, 4th Edition, McGraw Hill, 2010.

R3. C. I. Hubert, ***Electric Machines***, 2nd Edition, Pearson Education, 2001.

R4. P. K. Mukherjee and S. Chakraborty, ***Electrical Machines***, 2nd Edition, Dhanpat Rai Publications, 2011.

R5. B. S. Guruand and H. R. Hiziroglu, ***Electric Machinery and Transformers***, 3rd Edition, Oxford University Press, 2001.

R6. B. L. Theraja and A. K. Theraja, ***A Textbook of Electrical Technology (Vol.2) - AC and DC Machines***, 23rd Revised Edition, S Chand & Co, 2005.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105131/: by Prof. T. K. Bhattacharya, IIT Kharagpur
2. https://nptel.ac.in/courses/108/106/108106072/: by Prof. K. Vasudevan, Prof. G. S. Rao, Prof. P. S. Rao , IIT Madras
3. https://swayam.gov.in/nd1_noc20_ee38/preview

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

CO1	Describe the constructional details and performance of different types of synchronous generators.
CO2	Draw and explain the principles of operation and performance of synchronous motor.
CO3	Draw and describe the construction, operation and performance of 3-phase induction machines.
CO4	Describe the methods of starting and speed control of three-phase induction 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.

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

Type	Code	Engineering Thermodynamics	L-T-P	Credits	Marks
ES	18ES1T09		3-0-0	3	100

Objectives	The objective of this course is to introduce the theoretical and practical problems in classical thermodynamics with emphasis on analyses of various equilibrium processes & their applications to real-world engineering problems.
Pre-Requisites	Basic knowledge of physics, chemistry, 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 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, System, Control Volume, Surrounding, Boundaries, Universe, Types of Systems, Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic Equilibrium, State, Property, Process, Exact & Inexact Differentials, Point & Path functions, Cycle, Quasi-static Process, Reversibility and Irreversibility, Pressure measurement, Zeroth Law of Thermodynamics, Temperature, Principles of Thermometry, Constant Volume gas Thermometer, Temperature scale.	**9 Hours**
Module-2	Pure Substances, P-v, T-v, T-s and h-s diagrams, Phase Transformations, Triple point and critical state, Properties during change of phase, Dryness Fraction, Property tables; Perfect Gas Laws, Equation of State, Specific and Universal Gas constants, Various Non-flow processes, Properties and states.	**8 Hours**
Module-3	Heat and Work Transfer, Joule's Experiments, First law of Thermodynamics – Corollaries, First law applied to a Process, Internal energy, Enthalpy, PMM-I, First law applied to a flow system, Steady Flow Energy Equation, Nozzle, Diffuser, Throttling devices, Turbine, Compressor and Heat Exchanger.	**8 Hours**
Module-4	Limitations of the First Law, Thermal Reservoir, Heat Engine, Heat pump, Second Law of Thermodynamics, Kelvin-Planck and Clausius Statements and their Equivalence, Corollaries, PMM-II, Carnot's principle and cycle, Temperature scale, Entropy, Clausius Inequality, Principle of Entropy and its application, T-s plot, Entropy generation, Dead state, Quality of energy, Law of degradation of energy.	**9 Hours**
Module-5	Power Cycles - Otto, Diesel, Dual Combustion cycles, Description and representation on P-V and T-S diagram, Thermal Efficiency, Mean Effective Pressures, Application of Sterling Cycle, Atkinson Cycle, Ericsson Cycle, Joule Cycle, Comparison of Air standard Cycles, Refrigeration Cycles - Brayton and Rankine cycles.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. R. E. Sonntag and C. Borgnakke, ***Fundamentals of Thermodynamics***, 8th Edition, John Wiley & Sons,

2014.
T2. Y. A. Cengel and M. A. Boles, ***Thermodynamics - An Engineering Approach***, 7th Edition, McGraw-Hill Education, 2011.

Reference Books:

R1. P. K. Nag, ***Engineering Thermodynamics***, 5th Edition, McGraw Hill Education, 2013.
R2. Y. V. C. Rao, ***An Introduction to Thermodynamics***, 2nd Edition, University Press, 2004.

Online Resources:

1. https://nptel.ac.in/courses/112105123/: by Prof. S. K. Som, IIT Kharagpur
2. https://nptel.ac.in/courses/112/104/112104113/: by Prof. Y. V. C. Rao & Prof. G. Biswas, IIT Kanpur
3. https://nptel.ac.in/courses/112/105/112105220/: by Prof. S. K. Som & Prof. S. Chakraborty, IIT Kharagpur
4. https://www3.nd.edu/~powers/ame.20231/notes.pdf
5. https://ocw.mit.edu/courses/chemistry/5-60-thermodynamics-kinetics-spring-2008/

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

CO1	Describe the concepts of continuum, system, control volume, thermodynamic properties, thermodynamic equilibrium, temperature and pressure measurement.
CO2	Evaluate the properties of pure substances and gas mixtures.
CO3	Apply first laws of thermodynamics to analyze turbine, compressors, heat exchangers and nozzles.
CO4	Analyze the limitation of first law, need of second law, and evaluate the available energy and irreversibility.
CO5	Analyze of power cycles and refrigeration cycle and their 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.

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

Type	Code	Advanced Electronic Circuits	L-T-P	Credits	Marks
PE	18EC2T01		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.
R3. P. Horowitz and W. Hill, ***The Art of Electronics***, 3rd Edition, Cambridge University Press, 2015.

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	Transducers & Measurement Systems	L-T-P	Credits	Marks
PE	18EI2T02		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**: Definition of measurement, application & types of instruments, functional elements of generalized measurement systems, active/passive transducers, analog/digital mode of operation, null and deflection methods; **Static Characteristics**: Systematic characteristics, statistical characteristics, calibration; **Dynamic Characteristics**: Transfer functions of typical sensing elements, step and frequency response of first and second order elements, dynamic errors in measurement systems, dynamic compensation, loading effect, signal & noise.	**10 Hours**
Module-2	**Resistive Transducers**: 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 and 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 (Narrow Band & Broad Band), 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.	**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 Instrumentation and Control***, 4th Edition, PHI Learning, 2012.
T2. J. P. Bentley, ***Principles of Measurement Systems***, 4th Edition, PHI Learning, 2005.

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.

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 for 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.
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.

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

Type	Code	Electrical Engineering Materials	L-T-P	Credits	Marks
PE	18EE2T03		3-0-0	3	100

Objectives	The objective of this course is to study the properties and analysis of conductivity, dielectric strength, superconductivity, magnetization etc., of various engineering materials used in the field.
Pre-Requisites	Basic knowledge of engineering chemistry and physics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Elementary Materials Science Concepts: Bonding and types of solids, Crystalline state and their defects, Classical theory of electrical and thermal conduction in solids, Temperature dependence of resistivity, Skin effect, Hall effect.	**8 Hours**
Module-2	Dielectric Properties of Insulators in Static and Alternating field: Dielectric constant of mono-atomic gases, Poly-atomic molecules and solids, Internal field in solids and liquids, Properties of Ferro-Electric materials, Polarization, Piezoelectricity, Frequency dependence of Electronic and Ionic Polarizability, Complex dielectric constant of non-dipolar solids, Dielectric losses.	**12 Hours**
Module-3	Magnetic Properties and Superconductivity: Magnetization of matter, Magnetic Material Classification, Ferromagnetic Origin, Curie-Weiss Law, Soft and Hard Magnetic Materials, Superconductivity and its origin, Zero resistance and Meissner Effect, Critical current density.	**8 Hours**
Module-4	Conductivity of metals: Ohm's law and relaxation time of electrons, Collision time and mean free path, Electron scattering and resistivity of metals.	**6 Hours**
Module-5	Semiconductor Materials: Classification of semiconductors, Semiconductor conductivity, Temperature dependence, Carrier density and energy gap, Trends in materials used in Electrical Equipment.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. R. K. Rajput, ***A Course in Electrical Engineering Materials***, 1st Edition, Laxmi Publications, 2016.
T2. T.K.Basak, ***Electrical Engineering Materials***, 1st Edition, New Age International, 2009.

Reference Books:

R1. TTTI Madras, ***Electrical Engineering Materials***, 1st Edition, McGraw Hill Education, 2004.
R2. A. J. Dekker, ***Electrical Engineering Materials***, 1st Edition, PHI Publication, 2006.
R3. S. P. Seth and P. V. Gupta, ***A Course in Electrical Engineering Materials***, 1st Edition, Dhanpat Rai & Sons, 2011.

Online Resources:

1. https://nptel.ac.in/courses/113/106/113106032/by: Dr. R. Bauri, IIT Madras

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

CO1	Explain the fundamentals of classical theory of electrical and thermal conduction in solids.
CO2	Describe dielectric properties, polarization, and piezoelectrict effect.
CO3	Describe the concepts of magnetic properties of different materials and superconductivity.
CO4	Analyze conductivity properties and their implications of metals.
CO5	Analyze the conductivity properties and their implications of semiconductor materials.

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

Type	Code	Renewable Energy Systems	L-T-P	Credits	Marks
PE	18EE2T04		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	Signals & Systems	L-T-P	Credits	Marks
PE	18EC2T05		3-0-0	3	100

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

Evaluation Scheme

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

Detailed Syllabus

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

Cont'd...

Module-#	Topics	Hours
Module-5	**Sampling and Reconstruction**: Discrete-time system analysis using the Z-transform, The Sampling Theorem and its implications - Spectra of sampled signals; Reconstruction: ideal interpolator, Aliasing and its effects, Mapping from S-plane to Z-plane, Z-transform, the region of Convergence, Z- transform of some useful sequences, properties of Z-transform, Inverse Z-transform.	**8 Hours**
	Total	**42 Hours**

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

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

Type	Code	Applied Linear Algebra	L-T-P	Credits	Marks
OE	18BS3T01		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	18BS3T02		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 and Fluid Statics - Density, Specific weight, Specific gravity. Viscosity, vapor pressure, compressibility; Pressure at a point, Pascal's Law and pressure variation with temperature, Density and altitude; Simple and differential manometers, Piezometer, Pressure gauges; Hydrostatic forces on submerged surface, Forces on horizontal and vertical submerged plane surfaces; Buoyancy and flotation, Archimedes' principle, Metacentric height, Stability of immersed and floating bodies.	**9 Hours**
Module-2	Introduction, Kinematics of fluid flow, Lagrangian and Eulerian descriptions, Conservation of mass -Continuity equation, Differential equation of continuity, Stream line, Path line, Streak lines and Stream tube, Reynolds number and Classification of fluid flow - Steady & unsteady, Uniform & non-uniform, Laminar & turbulent, Rotational & irrational; One, Two and Three-dimensional flows.	**8 Hours**
Module-3	Dynamics of Inviscid flows, Surface and body forces, Derivation of Euler's equation and Bernoulli's equation, Applications of Bernoulli's Equation - Venturi meter, Orifice meter, Current meter, Pitot tube; Viscous flow in a pipe/duct - Head loss, Friction factor, Frictional loss in high Reynolds number flow, Effect of wall roughness, Moody chart & illustration by examples; Losses in pipe systems - Pipe entrance/exit, Expansion/contraction, Fittings, Valves, Water level, Velocity & discharge measurements.	**9 Hours**
Module-4	Brief discussion on acceleration of fluid particles, Continuity equation in 3D flow, Stream function, Velocity potential function; Dynamics of viscous fluids; Momentum balance equation, Control volume approach, Navier-Stokes equations in Cartesian form, Principles of Dimensional Analysis and Similarity, Notch and weir, Impact of Jet, and relevant equations.	**8 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	Construction and working principles of - Hydraulic turbines, Impulse turbines, Reaction and Mixed Flow turbines, Hydraulic pumps, Centrifugal pumps & positive displacement types, Characteristic curves of Hydraulic turbines (NHQ).	**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	Analyze different types of fluid flow and evaluate different flow parameters.
CO3	Apply the concepts of fluid dynamics for the flow measuring devices and pipe flows.
CO4	Analyze free surface and 3D flow characteristics and apply them to engineering problems.
CO5	Visualize the construction & working principles of various 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.

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	
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	Electronic Devices & Modeling	L-T-P	Credits	Marks
OE	18EC3T03		3-0-0	3	100

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

T1. G. Massobrio and P. Antognetti, ***Semiconductor Device Modeling with SPICE***, 2nd Edition, McGraw-Hill Education, 2010.

T2. D. K. Schroder, ***Semiconductor Material and Device Characterization***, 3rd Edition, John Wiley & Sons, 2006.

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

P.T.O

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

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

Type	Code	Fundamentals of DBMS	L-T-P	Credits	Marks
OE	18CS3T04		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 currency 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	Biomedical Instrumentation & Signal Processing	L-T-P	Credits	Marks
OE	18EI3T05		3-0-0	3	100

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

Evaluation Scheme

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

Detailed Syllabus

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

Text Books:

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

Reference Books:

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

Online Resources:

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

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

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

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Cont'd...

PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

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

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

Type	Code	Power Electronics Lab	L-T-P	Credits	Marks
PC	18EE1L05		0-0-2	1	100

Objectives	The objective of this laboratory is to provide practical exposure on analysis, design & testing of power electronics converters along with application of semiconductor devices for conversion and control of electrical energy.
Pre-Requisites	Knowledge of different electrical components, semiconductor devices and analysis of electrical & magnetic circuits is required. Topics taught in Power Electronics theory class are essential to conduct the experiments.
Teaching Scheme	Regular laboratory experiments to be conducted under supervision of the faculty. Demonstration and associated safety measures will be explained for each experiment in the pre-lab sessions.

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 the V-I characteristics of SCR and to measure the latching and holding current of a SCR.
2	Study of the V-I characteristics of UJT.
3	Study of the V-I characteristics of TRIAC.
4	Study of UJT triggering circuit and cosine controlled triggering circuit.
5	Study of single phase half wave and full wave (Bridge type) controlled rectifier with R and R-L Load.
6	Study of the single phase full wave controlled rectifier (Mid-point type) and semi converter with R and R-L Load.
7	Study of three phase full wave controlled rectifier (Full and Semi converter) with R and R-L Load.
8	Study of the forward converter and Flyback converter.
9	Study of the single-phase voltage source inverter with Sinusoidal pulse width modulation.
10	Study of dual converter in (i) circulating and (ii) non-circulating current modes.
11	Simulate various power electronics converter circuits and study their performance.

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.
5. https://www.coursera.org/learn/power-electronics

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

CO1	Interpret the characteristics of SCR, UJT and TRIAC and study the triggering circuit of SCR & TRIAC.
CO2	Analyze various power electronics converters.
CO3	Evaluate the performance of Dual converter and its applications.
CO4	Simulate different power electronic converters.

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

Type	Code	Electrical Machines - II Lab	L-T-P	Credits	Marks
PC	18EE1L07		0-0-4	2	100

Objectives	The objective of this laboratory course is to provide practical exposure to different electrical machines and help understand & verify the concepts of electrical machines, calculate different parameters like voltage regulation, efficiency & losses and their effect on performance. The laboratory experiments shall go hand-in-hand with the topics taught in the theory class.
Pre-Requisites	Knowledge of Basic Electrical Engineering, Physics and knowledge of Basic Mathematics such as Calculus, ordinary differential equations is required.
Teaching Scheme	Regular laboratory experiments to be conducted under supervision of the faculty with demonstration and simulation-based verification for the experiments to be conducted.

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
	Hardware based Experiments
1	Determination of the voltage regulation of an alternator by synchronous impedance method.
2	Determination of the voltage regulation of an alternator by MMF method.
3	Determination the voltage regulation of an alternator by ZPF method.
4	Measurement of direct and quadrature axis reactance of salient pole synchronous machine. Also, find the voltage regulation of a salient pole synchronous generator.
6	Study of parallel operation of two alternators.
6	To determine the power angle characteristics of an alternator.
7	Speed control of 3-ϕ induction motor using variable frequency control.
8	Determination of efficiency, plotting of torque-slip characteristics of 3-ϕ slip ring induction motor by electrical loading.
9	Determination of parameters of 3-ϕ induction motor from No load and Blocked Rotor Test.
10	To perform no load and block rotor test and determine the parameters of a single-phase capacitor start induction motor.
11	To operate a 3-ϕ induction motor as induction generator.
12	Performance analysis of an universal motor by direct loading.
	Software based Experiments
13	Create a program that models the behavior of a rotating magnetic field in the 3-ϕ stator.
14	Create a program that models the behavior of the terminal voltage of a synchronous generator with change in its load current with lagging, leading and UPF load.

Cont'd...

Experiment-#	Assignment/Experiment
15	Create a program to calculate and plot I_a versus I_f for a synchronous motor with a constant load - (V curve).
16	Create a program to calculate and plot the torque-speed characteristic of the 3-ϕ induction motor both with the original rotor resistance and with the doubled rotor resistance.
17	Create a simulation model to show the torque produced in a 1-ϕ induction motor based on double field rotating theory.

Text Books:

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

Reference Books:

R1. P. S. Bimbhra, ***Electrical Machines***, 2nd Edition, Khanna Publishers, 2017.
R2. D. P. Kothari and I. J. Nagrath, ***Electrical Machines***, 4th Edition, McGraw Hill, 2010.
R3. C. I. Hubert, ***Electric Machines***, 2nd Edition, Pearson Education, 2001.
R4. P. K. Mukherjee and S. Chakraborty, ***Electrical Machines***, 2nd Edition, Dhanpat Rai Publications, 2011.
R5. B. S. Guruand and H. R. Hiziroglu, ***Electric Machinery and Transformers***, 3rd Edition, Oxford University Press, 2001.
R6. B. L. Theraja and A. K. Theraja, ***A Textbook of Electrical Technology (Vol.2) - AC and DC Machines***, 23rd Revised Edition, S Chand & Co, 2005.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105131/: by Prof. T. K. Bhattacharya, IIT Kharagpur
2. https://nptel.ac.in/courses/108/106/108106072/: by Prof. K. Vasudevan, Prof. G. S. Rao, Prof. P. S. Rao, IIT Madras
3. https://swayam.gov.in/nd1_noc20_ee38/preview

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

CO1	Determine voltage regulation of a Synchronous generators by various methods and compare the results for accuracy.
CO2	Evaluate the performance of a Salient pole synchronous machine.
CO3	Demonstrate synchronization of two synchronous generators for sharing a common load.
CO4	Assess the performance of three phase and single phase induction motor in specific applications.
CO5	Simulate the performance characteristics of synchronous machine and induction machine using MATLAB and intrepret the 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.

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

Type	Code	Soft Skills & Interpersonal Skills Lab	L-T-P	Credits	Marks
HS	18HS1L02		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	Communication in a nutshell.
2	Communication in a nutshell.
3	Mock GD 1
4	Mock GD 2
5	Mock GD 3
6	Mock GD 4 (Test)
7	Personality Development
8	Assertiveness
9	Teamsmanship
10	Leadership
11	Listening
12	Presentation Skills 1
13	Presentation Skills 2
14	Presentation Skills 3
15	Presentation Skills 4
16	Personal Interview 1
17	Personal Interview 2
18	Personal Interview 3
19	Personal Interview 4
20	Mind Mapping
21	Reading Skills 1
22	Reading Skills 2

Cont'd...

Experiment-#	Assignment/Experiment
23	Writing Skills 1
24	Writing Skills 2
25	Writing Skills 3
26	Verbal Ability 1
27	Verbal Ability 2
28	Verbal Ability 3

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

Cont'd...

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	Electrical Power Transmission & Distribution	L-T-P	Credits	Marks
PC	18EE1T08		3-0-0	3	100

Objectives	The objective of the course is to study the basic concept of power system, its components and parameters, characteristics of power lines for different voltage levels, and the equipment used in power transmission & distribution.
Pre-Requisites	Knowledge of AC and DC circuits, characteristics & response of the electrical parameters (R, L, and C), and elementary idea on electrical power system and components 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 power system, Transmission Line Parameters: Types of conductors, Resistance, Inductance of a conductor due to internal flux, Flux linkages between two points, Inductance Calculation: Composite-conductor, Single-phase line, Three-phase line with equilateral & unsymmetrical spacing, Bundled conductors; Skin effect, Kelvin's economy law & limitations, Electric field of long & straight conductor, Potential difference between two points due to a charge, Capacitance Calculation: Two-wire line, 3-phase line with equilateral & unsymmetrical spacing, Effect of earth on capacitance of a 3-Phase line, Bundled conductors, Parallel circuit 3-phase lines.	**12 Hours**
Module-2	Transmission Line Performance: Short & medium transmission lines - representation as π & T model, ABCD parameter, Performance analysis; Long Transmission Lines: Hyperbolic form of equations & its interpretation, ABCD parameters, Equivalent π and T network; Power flow through transmission line, Causes of low power factor and its effect, Power factor improvement & its economics, Power factor correction by static capacitor.	**8 Hours**
Module-3	Overhead Line Insulators: Insulator materials, Types of insulators; Voltage distribution over insulator string, Improvement of string efficiency, Insulation failure; Mechanical Design of Overhead Transmission Lines: General considerations, Span, Conductor configuration, Spacing and clearances, Sag & tension, Factors affecting sag, Conditions for tower erection; Catenary, Conductor vibration, Corona.	**8 Hours**
Module-4	Distribution Systems: Types, AC 3-phase 4-wire distribution system, Primary & secondary distribution system, Voltage drop in DC & AC distributors, Design of distribution substation, Design of secondary network, Application of capacitors and filters.	**6 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	Underground Cables: Cable insulation, Sheath, Armour & covering, Classification of cables, Pressurized cables, Effective resistance, Inductive reactance & capacitance of single-core & 3-phase belted cables, Breakdown of cables, Cable installation, System operating problems with underground & HVDC cables; Power System Earthing: Types and methods, Earth resistance, Design of earthing grid, Tower footing resistance, Neutral grounding.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. J. Grainger and W. D. Stevenson Jr., ***Power System Analysis***, 1st Edition, McGraw Hill, 2017.
T2. B. R. Gupta, ***Power System Analysis and Design***, 3rd Edition (Reprint), S. Chand Publications, 2003.
T3. H. Cotton and H. Barber, ***The Transmission and Distribution of Electrical Energy***, 4th Edition, Hodder Arnold, 1963.

Reference Books:

R1. M. S. Naidu and V. Kamaraju, ***High Voltage Engineering***, 5th Edition, McGraw Hill, 2013.
R2. D. P. Kothari and I. J. Nagrath, ***Power System Analysis***, 4th Edition, McGraw Hill, 2011.

Online Resources:

1. https://nptel.ac.in/courses/108102047/: by Prof. D. P. Kothari, IIT Delhi
2. https://nptel.ac.in/courses/117101056/: by Prof. R. K. Shevgaonkar, IIT Bombay

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

CO1	Evaluate the resistance, inductance and capacitance present in the power lines and the characteristics of these line parameters.
CO2	Analyze the performance of the transmission lines under different operating conditions.
CO3	Design the mechanical and insulation system of transmission lines.
CO4	Design AC & DC distribution system with capacitors and filters.
CO5	Get an insight of the underground cables, their construction and requirement of earthing.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

Cont'd...

PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

Type	Code	Introduction to Digital Signal Processing	L-T-P	Credits	Marks
PC	18EC1T09		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	Fundamentals of Microprocessors & Microcontrollers	L-T-P	Credits	Marks
PC	18EC1T10		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, Embedded versus External Memory Devices, 8-bit and 16-bit Microcontrollers, 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.

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

Type	Code	Advanced Power Electronics	L-T-P	Credits	Marks
PE	18EE2T06		3-0-0	3	100

Objectives	The objective of this course is to study different advanced topics in power electronics including rectifiers, inverters, resonant & soft-switching converters, power converter and its industrial applications.
Pre-Requisites	Knowledge of circuit topology, analysis of switching circuits, magnetics, power semiconductor devices, and basic simulation skill is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on advanced topics of power electronics.

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	Non-isolated DC-DC Converters: Buck, Boost, Buck-boost, Cuk, SEPIC (single-ended primary-inductor converter), Isolated DC-DC converters (Switched Mode Power Supplies (SMPSs)): Forward converter, Fly back converter, Half bridge converter, Full bridge converter, Push-pull converter.	**12 Hours**
Module-2	Resonant Converters: Series Resonant Converters, Parallel Resonant Converters, Zero-voltage-switching (ZVS) resonant converters, Zero-current-switching (ZCS) resonant converters, Resonant DC-link converters.	**7 Hours**
Module-3	Switched Mode AC Power Supplies: UPS systems, Resonant AC power supplies, Control techniques (PWM controller and isolation in the feedback loop).	**5 Hours**
Module-4	Inverters: Voltage Source Inverters (VSIs): Pulse width modulation (PWM) techniques: Sine PWM (SPWM), Selected harmonic elimination PWM (SHEPWM), Space vector PWM (SVPWM), Hysteresis band current controlled PWM; Three level inverters, Resonant inverters, Soft switched inverters; Current Source Inverters (CSIs): Load commutated inverters, Forced commutated inverters.	**12 Hours**
Module-5	AC Voltage Controllers: AC voltage controllers with PWM control; Applications: HVDC transmission, Active harmonic filter, Grid integration of renewable energy sources with energy storage system.	**8 Hours**
	Total	**44 Hours**

Text Books:

T1. M. H. Rashid, ***Power Electronics***, 3rd Edition, PHI Learning, 2008.
T2. N. Mohan, T. M. Undeland, and W. P. Robbin, ***Power Electronics : Converters, Applications and Design***, 3rd Edition, Wiley India, 2012.
T3. B. K. Bose, ***Modern Power Electronics and AC Drives***, 1st Edition, Pearson Education, 2005.

Reference Books:

R1. B. W. Flynn and D. E. Macpherson, ***Switched Mode Power Supplies : Design and Construction***, 2nd Edition, Universities Press, 1997.

Online Resources:

1. https://nptel.ac.in/courses/108/107/108107128/: by Prof. A. Bhattacharya, IIT Roorkee
2. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-334-power-electronics-spring-2007/lecture-notes/

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

CO1	Describe the working of isolation and non-isolation type DC-DC converter with its analysis.
CO2	Explain operations of different types of resonating converters.
CO3	Design and analyse various AC power supplies with their control techniques.
CO4	Identify the operation of advanced converters and switching techniques implemented in recent technology.
CO5	Apply AC voltage controllers and power electronics devices in various real world scenarios.

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

Type	Code	Advanced Control Systems	L-T-P	Credits	Marks
PE	18EE2T07		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	Electrical Drives	L-T-P	Credits	Marks
PE	18EE2T08		3-0-0	3	100

Objectives	The objective of this course is to study different power electronics converters used for drives and their industrial applications.
Pre-Requisites	Knowledge of power electronics, electrical machines, and basic simulation skill is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on power electronics and machine drives.

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	Study of motor drives: Fundamentals of drives and its block diagram, Selection of drives, Classification, Nature and components of load torques, Fundamental torque equations, Determination of equivalent drive parameters, Time and energy calculation in transient operations, Speed-torque conventions and Multi-quadrant operation, Steady-state stability, Load equalizations, Thermal model of motor, Classes of motor duty, Rating based on thermal consideration; Control of Electrical drives: Current limit control, Closed-loop torque control, Closed-loop speed control and closed-loop position control.	**12 Hours**
Module-2	Performance of DC drives: DC motors and their performances, Starting, Braking, Speed control: Methods of armature voltage control, Controlled rectifier based DC drives, Chopper controlled DC drive.	**7 Hours**
Module-3	Performance of AC drives: Induction motor drives - Static speed control: Stator voltage control, V/f control, Constant torque and constant power operation, VSI controlled drive, CSI controlled drive, Current regulated VSI control, Static rotor resistance control, Static slip power recovery scheme; Synchronous motor drive - True and self-synchronous mode.	**10 Hours**
Module-4	Electric traction: Traction system mechanics: Speed-time and distance-time curves, Tractive effort, Effective weight, Train resistance, Adhesive weight, Specific energy output and consumption, Traction motor.	**7 Hours**
Module-5	Industrial application of drives: Steel rolling mills, Textile mills, Cement mills, Paper mills, etc.; Microprocessor applications in drive systems.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. G. K. Dubey, ***Fundamentals of Electrical Drives***, 3rd Edition, Norasa Publishing, 2010.
T2. S. K. Pillai, ***First Course on Electrical Drives***, 3rd Edition, New Age International, 2012.
T3. V. Subrahmanyam, ***Electric Drives***, 2nd Edition, McGraw Hill Education, 2017.

Reference Books:

R1. M. H. Rashid, ***Power Electronics***, 3rd Edition, PHI Learning, 2008.
R2. B. K. Bose, ***Modern Power Electronics and AC Drives***, 1st Edition, Pearson Education, 2005.

Online Resources:

1. https://nptel.ac.in/courses/108/104/108104140/: by Prof. S. P. Das, IIT Kanpur

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

CO1	Explain classes of electric drive systems, selection of drives, steady-state stability, thermal modeling and control of electrical drives.
CO2	Design & analyze performance of DC drives under steady-state and transient conditions.
CO3	Design & analyze performance of AC drives under steady-state and transient conditions.
CO4	Describe the internals of electrical traction systems and their mechanics.
CO5	Identify appropriate electric drives for industrial use and develop the skills for application of microprocessors in drive 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	1							1	3	2	1
CO2	3	3	2	2	2							1	2	2	
CO3	3	3	2	2	1							1	2	2	
CO4	3	3	3	2	3							1	3	1	
CO5	3	2	2	2	3							1	2	1	1

Type	Code	IoT & Applications	L-T-P	Credits	Marks
PE	18EI2T09		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, 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	Analog Communication	L-T-P	Credits	Marks
PE	18EC2T10		3-0-0	3	100

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

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Signals and Spectra: An Overview of Electronic Communication Systems, Types of 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), Square-law modulator, Switching Modulator , Balanced Modulator, Square-law detector, Envelope detector, Synchronous detector, Single Side Band with Suppressed Carrier (SSB-SC), Frequency discrimination method, Phase discrimination method, Coherent detection, Modulation and demodulation of Vestigial Side Band Modulation (VSB) and Frequency Division Multiplexing, Radio Transmitter and Receiver (super heterodyne receiver).	**9 Hours**
Module-3	Angle Modulation: Angle Modulation, Narrow & Wide band FM, FM Modulators: Direct method (Varactor diode method), Indirect method (Armstrong method), Simple slope detector, Balanced Slope detector, Phase Locked Loop (PLL); Pulse Modulation & Digital Transmission of Analog Signal: Analog to Digital (Noisy Channel & Role of Repeater), Sampling Theorem, Pulse Amplitude Modulation, Pulse Width Modulation & Pulse Position Modulation, Time Division Multiplexing, Digital Representation of Analog Signal, Pulse Code Modulation (PCM).	**8 Hours**
Module-4	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**

Cont'd...

Module-#	Topics	Hours
Module-5	Noise in Amplitude Modulation System: Framework for Amplitude Demodulation, Calculation of signal to noise ratio: Single Sideband Suppressed Carrier (SSB-SC), Double Sideband Suppressed Carrier (DSB-SC), Double Sideband With Carrier (DSB-C), Threshold effect in AM; Noise in Frequency Modulation System: An FM Receiving System, Calculation of Signal to Noise Ratio, Comparison of FM & AM, Pre-emphasis, De-emphasis, SNR Improvement, Threshold in Frequency Modulation, The FM Demodulator using Feedback (FMFB).	**9 Hours**
	Total	**42 Hours**

Text Books:

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

Reference Books:

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

Online Resources:

1. https://nptel.ac.in/courses/117105143/: by Prof. G. Das, IIT Kharagpur
2. https://www.iare.ac.in/sites/default/files/lecture_notes/IARE_ECE_AC_NOTES_0.pdf
3. http://www.vssut.ac.in/lecture_notes/lecture1500382945.pdf

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, pulse modulation schemes and digital transmission of analog signals.
CO4	Visualize the behavior of random variables, noise signal in frequency domain, and linear filtering of noise.
CO5	Analyze the performance of AM & FM systems in presence of noise signals.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

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

Type	Code	HVDC Transmission	L-T-P	Credits	Marks
PE	18EE2T11		3-0-0	3	100

Objectives	The objective of this course is to study various aspects of power transmission through high-voltage DC including control, conversion, harmonics, faults, and other engineering design considerations.
Pre-Requisites	Knowledge of circuit topology, analysis of switching circuits, magnetics, power semiconductor devices, and basic simulation skill 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: Comparison of AC and DC transmission systems, Reliability and application of DC transmission, Types of DC links, Typical layout of a HVDC converter station. HVDC converters, Pulse number, Converter bridge characteristics, Equivalent circuits of rectifier and inverter configurations of twelve pulse converters.	**8 Hours**
Module-2	HVDC Transmission: General classes of power quality problems, Transients, Long duration voltage variations, Short-duration voltage variations, Voltage imbalance, Waveform distortion, Voltage fluctuations, Power frequency variations, Power quality terms; 6-Pulse Converter Operation and Analysis: Sources of sags and interruptions, Estimating voltage sag performance, Fundamental principles of protection, Solutions at the end-user level, Evaluating the economics of different ride-through alternatives, Motor starting sags, Utility system fault clearing Issues.	**10 Hours**
Module-3	Control of HVDC Converter and Systems: Mechanism of AC power transmission, Principle of control, Necessity of control in case of a DC link, Rectifier control, Compounding of rectifiers, Power reversal in a DC link, Voltage dependent current order limit (VDCOL), Characteristics of the converter, System control hierarchy and Basic philosophy, Inverter extinction angle control (EAG), Pulse phase control, Starting and stopping of a DC link, Constant power control, Control systems for HVDC converters, Inverter operation problems, Control of VSC converters.	**8 Hours**
Module-4	Harmonics in HVDC Systems: Importance of harmonic study, Generation of harmonics by converters, Characteristic harmonics on the DC Side, Characteristic current harmonics, Characteristic variations of harmonic currents with variation of α & μ, Effect of control modes on harmonics, Non-characteristic harmonics, Harmonics in VSC converters; Valve configuration, Converter theory, Types of DC links, Converter station, Priniciple of DC link control and characteristics.	**8 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	Harmonic Suppression in HVDC System Filters: Harmonic model & equivalent circuit, Use of filters, Filter configurations, Design of Band-Pass & High-Pass filters, Protection of filters, DC filters; Faults and Protection Schemes: Nature and types of faults, Faults on AC side of converter stations, Converter faults, Faults on DC side of the system, Protection against over currents/voltages, Protection of filter units; Multi-terminal HVDC Systems: Types, Parallel operation aspects, Paralleling (Disconnecting) of units or converter, Control of power, VSC multi-level DC systems; Types of converter faults, Converter station protection against faults, Harmonics and filters, Starting, Stopping and power flow reversal.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. K. R. Padiyar, ***HVDC Power Transmissions Systems : Technology & Systems Interaction***, 3rd Edition, New Age Publication, 2017.

Reference Books:

R1. S. Kamakshaiah and V. Kamaraju, ***HVDC Transmission***, TMH Education, 2011.
R2. M. H. Rashid, ***Power Electronics***, 3rd Edition, PHI Learning, 2008.

Online Resources:

1. https://nptel.ac.in/courses/108/104/108104013/: by Dr. S. N. Singh,IIT Kanpur
2. https://www.cet.edu.in/noticefiles/229_HVDC_NOTE.pdf

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

CO1	Explain HVDC Transmission Systems and converter circuits.
CO2	Examine different power quality problems associated with HVDC transmission systems.
CO3	Design and analyse various control techniques for HVDC converters.
CO4	Evaluate harmonics in HVDC transmission system and their effect.
CO5	Develop harmonic suspension and protection systems for HVDC transmission.

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

Type	Code	Numerical Optimization	L-T-P	Credits	Marks
OE	18BS3T06		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	18BS3T07		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	Introduction: Concept and Importance of Organizational Behaviour; Learning-Nature of Learning, Components of learning, Learning Cycle, Theories of Learning; Personality - Concept, Determinants of Personality, Personality Traits, Personality and OB.	**9 Hours**
Module-2	Perception and Motivation: Perception - The Concept of Perception, The perceptual process, Importance of Perception in OB; Motivation: Nature and Importance, Herzberg's Two Factor Theory, Maslow's Need Hierarchy Theory, Alderfer's ERG Theory.	**8 Hours**
Module-3	Organizational Behaviour Process: Communication-Concept, Importance, Types, Gateways and Barriers to Communication; Communication as a tool for improving Interpersonal Effectiveness. Groups in Organizations: Nature and Types of Groups, Group Cohesiveness and Group Decision-making with Managerial Implications, Effective Team Building. Leadership: Leadership and Management, Theories of Leadership, Conflict-Nature of Conflict and Conflict Resolution.	**9 Hours**
Module-4	Organizational Culture and Human Resource Management: Organizational Culture: Concept of Organizational Culture and Organizational Effectiveness; 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: Cultural Differences and Similarities, Individual and Interpersonal Behavior in Global Perspective, Trends in International Business.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. K. Davis, ***Organisational Behaviour***, 9th Edition, McGraw-Hill, 1992.
T2. K. Aswathappa, ***Organisational Behaviour***, 12th Rev. 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	Adaptive Signal Processing	L-T-P	Credits	Marks
OE	18EC3T08		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	Operating Systems	L-T-P	Credits	Marks
OE	18CS3T09		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.

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	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	18CS3T10		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	Industrial Automation & Control	L-T-P	Credits	Marks
OE	18EI3T11		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.
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.

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	Introduction to Digital Signal Processing Lab	L-T-P	Credits	Marks
PC	18EC1L09		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. R. Pratap, ***Getting Started with MATLAB : A Quick Introduction for Scientists & Engineers***, 1st South Asia Edition, Oxford University Press, 2010.
R2. S. S. Kumar and S. V. B. Lenina, ***MATLAB: Easy Way Of Learning***, 1st Edition, PHI Learning, 2016.
R3. L. R. Rabiner and B. Gold, ***Theory and Application of Digital Signal Processing***, 2nd Edition, Prentice Hall India, 1992.
R4. J. R. Johnson, ***Introduction to Digital Signal Processing***, 2nd Edition, Prentice Hall India, 1992.
R5. A. N. Kani, ***Signals and Systems***, 2nd Edition, McGraw Hill Education, 2010.
R6. P. R. Babu, ***Digital Signal Processing***, 4th Edition, SciTech Publication, 2011.

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.

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	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	Fundamentals of Microprocessors & Microcontrollers Lab	L-T-P	Credits	Marks
PC	18EC1L10		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	Electrical Power Transmission & Distribution Lab	L-T-P	Credits	Marks
PC	18EE1L08		0-0-2	1	100

Objectives	The objective of this laboratory is to investigate the performance of power lines in a transmission & distribution system by calculating different line parameters & power flows in the power lines, and software analysis for power system problem solving.
Pre-Requisites	Basic knowledge of AC & DC network analysis, general idea on power system equipment and relation between real & reactive power is required.
Teaching Scheme	Regular laboratory experiments should be conducted under supervision of the teacher. Demonstration and necessary safety measures will be explained for each experiment in the pre-lab sessions.

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 Ferranti effect using transmission system kit.
2	Determination of ABCD parameters using transmission system kit.
3	Study of series and shunt compensation in transmission system kit.
4	Distribution system power factor improvement using switched capacitor.
5	Break down of voltage (BDV) test of transformer oil.
6	Determination of string efficiency.
7	Study of Corona discharge (both visual and auditory).
8	Measurement of Earth resistance using earth resistance tester.
9	Study of various lightening arrester.
10	Calculation of line parameters using tower configuration.

Text Books:

T1. J. J. Grainger and W. D. Stevenson Jr., ***Power System Analysis***, 1st Edition, McGraw Hill, 2017.
T2. B. R. Gupta, ***Power System Analysis and Design***, 3rd Edition (Reprint), S. Chand Publications, 2003.

Reference Books:

R1. M. S. Naidu and V. Kamaraju, ***High Voltage Engineering***, 5th Edition, McGraw Hill, 2013.
R2. D. P. Kothari and I. J. Nagrath, ***Power System Analysis***, 4th Edition, McGraw Hill, 2011.
R3. H. Cotton and H. Barber, ***The Transmission and Distribution of Electrical Energy***, 4th Edition, Hodder Arnold, 1963.

Online Resources:

1. https://nptel.ac.in/courses/108102047/: by Prof. D. P. Kothari, IIT Delhi
2. https://nptel.ac.in/courses/117101056/: by Prof. R. K. Shevgaonkar, IIT Bombay

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

CO1	Explain the practical effect of the line parameters in transmission line.
CO2	Evaluate the significance of no load, light load or heavy load in transmission line.
CO3	Investigate the different methods to improve the power factor.
CO4	Analyze the performance of insulation (solid and liquid) and study the earth resistance.
CO5	Design the mechanical structure of the power lines.

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

Type	Code	Skill Lab & Project - I	L-T-P	Credits	Marks
PJ	18EE6L03		0-0-4	2	100

Objectives	The objective of the laboratory course is to enhance the software & hardware skills of students, design electrical/electronic circuits for specific applications by utilizing the knowledge gained in previous semesters, analyze & optimize the designs through simulation, introduce latest research areas in electrical & electronics engineering.
Pre-Requisites	Basic electrical engineering, basics of software, circuit theory, control systems, power electronics, renewable energy systems, etc., are required.
Teaching Scheme	Regular laboratory experiments should be conducted under supervision of the teacher. Demonstration and necessary safety measures will be explained for each experiment in the pre-lab sessions.

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
	Software Skills
1	Introduction to Programming & Simulation software.
2	Verification of Network Theorems: Superposition, Thevenin, Norton, Reciprocity & Maximum Transfer Theorem. Study of Series/Parallel Resonance Circuit.
3	Design of PID Controller using Ziegler-Nichols tuning method and automated tuning method.
4	Design of Compensator networks for given frequency domain specification.
5	Study of uncontrolled & controlled 1-phase rectifier for R, RL, RLE load.
6	Study of uncontrolled & controlled 3-phase rectifier for R, RL, RLE load.
7	Model of PV module and study of I-V and P-V characteristics using Simulation techniques.
8	Study of Transmission line performance using ABCD parameter approach.
	Hardware Skills
1	Design of variable DC supply.
2	Study of House Wiring with energy calculation.
3	Design and control of PE converters using microcontrollers.
4	Speed Control of Universal Motor using triac circuit.
5	Transformer Design: Shell type, 12-0-12 V, 5A center tapped transformer.
6	Study and design of Fan winding.
	Project Work
1	Software-based Project, presentation & viva-voce
2	Hardware-based Project, presentation & viva-voce

Text Books:

T1. S. Attaway, ***MATLAB : A Practical Introduction to Programming and Problem Solving***, 3rd Edition, Butterworth-Heinemann, 2013.
T2. C. K. Alexander and M. N. O. Sadiku, ***Fundamentals of Electric Circuits***, 6th Edition, McGraw Hill Education, 2019.
T3. M. H. Rashid, ***Power Electronics : Devices, Circuits and Applications***, 4th Edition, Pearson Education, 2017.
T4. K. Ogata, ***Modern Control Engineering***, 5th Edition, PHI Learning, 2010.

Reference Books:

R1. A. K. Tyagi, ***MATLAB and Simulink for Engineers***, Pap/Cdr Edition, Oxford, 2011.
R2. J. Pyrhonen, T. Jokinen, and V. Hrabovcova, ***Design of Rotating Electrical Machines***, 2nd Edition, Wiley, 2013.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105066/
2. https://nptel.ac.in/courses/108/107/108107115/
3. https://nptel.ac.in/courses/108/106/108106075/
4. https://nptel.ac.in/courses/108/106/108106098/

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

CO1	Develop programs in MATLAB for different application in electrical engineering.
CO2	Design different controllers and compensators used in control system applications.
CO3	Acquire the skill for designing power electronics devices using appropriate hardware and software.
CO4	Conceive innovative project ideas in different electrical & electronics applications.
CO5	Design and troubleshoot the winding of cell type transformers and domestic fans.

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.
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.

Cont'd...

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

Part IV

4th Year B. Tech. (EEE)

Curriculum Structure (Regular)

Semester VII									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
PC	18EE1T09	Power Systems Operation & Control	3	0	0	3	0	0
PC	18EE1T10	Power System Protection	3	0	0	3	0	0
PE	18**2T**	Professional Elective - IV	3	0	0	3	0	0
PE	18**2T**	Professional Elective - V	3	0	0	3	0	0
HS	18HS1T03	Fundamentals of Management	3	0	0	3	0	0
OE	18**3T**	Open Elective - III	3	0	0	3	0	0
PRACTICAL									
PC	18EE1L09	Power Systems Lab	0	0	2	0	0	1
PJ	18IR6L04	Summer Internship - III	0	0	0	0	0	1
		SUB-TOTAL	**18**	**0**	**2**	**18**	**0**	**2**
		TOTAL	**20**			**20**		

Semester VIII									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
PE	18**2T**	Professional Elective - VI	3	0	0	3	0	0
OE	18**3T**	Open Elective - IV	3	0	0	3	0	0
PRACTICAL									
PJ	18IR6L05	Project - II	0	0	16	0	0	8
PJ	18IR6L06	Presentation Skills & Technical Seminar	0	0	4	0	0	2
VV	18VV6L07	Comprehensive Viva	0	0	0	0	0	1
		SUB-TOTAL	**6**	**0**	**20**	**6**	**0**	**11**
		TOTAL	**26**			**17**		

Note: *Courses offered under each elective are given in "List of Electives" on Page 205.*

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		
PRACTICAL									
PS	18PS6L08	Practice School / Industry Internship	0	0	0	0	0	16
PJ	18IR6L04	Summer Internship - III	0	0	0	0	0	1
		SUB-TOTAL	**0**	**0**	**0**	**0**	**0**	**11**
		TOTAL	**0**			**17**		

Semester VIII									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
PC	18EE1T09	Power Systems Operation & Control	3	0	0	3	0	0
PC	18EE1T10	Power System Protection	3	0	0	3	0	0
PE	18**2T**	Professional Elective - IV	3	0	0	3	0	0
PE	18**2T**	Professional Elective - V	3	0	0	3	0	0
HS	18HS1T03	Fundamentals of Management	3	0	0	3	0	0
OE	18**3T**	Open Elective - IV	3	0	0	3	0	0
PRACTICAL									
PC	18EE1L09	Power Systems Lab	0	0	2	0	0	1
VV	18VV6L07	Comprehensive Viva	0	0	0	0	0	1
		SUB-TOTAL	**18**	**0**	**2**	**18**	**0**	**2**
		TOTAL	**20**			**20**		

Note: *Subjects under each elective shall be same as those for Regular students (Page 205).*

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									
PC	18EE1T09	Power Systems Operation & Control	3	0	0	3	0	0
PC	18EE1T10	Power System Protection	3	0	0	3	0	0
PE	18**2T**	Professional Elective - IV	3	0	0	3	0	0
PE	18**2T**	Professional Elective - V	3	0	0	3	0	0
HS	18HS1T03	Fundamentals of Management	3	0	0	3	0	0
OE	18**3T**	Open Elective - III	3	0	0	3	0	0
PRACTICAL									
PC	18EE1L09	Power Systems Lab	0	0	2	0	0	1
PJ	18IR6L04	Summer Internship - III	0	0	0	0	0	1
		SUB-TOTAL	**18**	**0**	**2**	**18**	**0**	**2**
		TOTAL	**20**			**20**		

Semester VIII									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
PRACTICAL									
PS	18PS6L08	Practice School / Industry Internship	0	0	0	0	0	16
VV	18VV6L07	Comprehensive Viva	0	0	0	0	0	1
		SUB-TOTAL	**0**	**0**	**0**	**0**	**0**	**17**
		TOTAL	**0**			**17**		

Note: *Subjects under each elective shall be same as those for Regular students (Page 205).*

List of Electives

Code	Elective # and Subjects
	Professional Elective - IV
18EI2T12	Introduction to VLSI Design
18EC2T13	Digital Image & Video Processing
18EE2T14	Soft Computing Techniques
18EE2T15	Flexible AC Transmission System
	Professional Elective - V
18EC2T16	Digital Communication
18EC2T17	Microwave Engineering
18EE2T18	Power Quality
18EE2T19	Smart Grid
	Professional Elective - VI
18EC2T20	Mobile Communication & Networks
18EE2T21	PLC & SCADA
18EE2T22	High Voltage Engineering
	Open Elective - III
18BS3T12	[BSH] Stochastic Process
18BS3T13	[BSH] Project Management
18EC3T14	[ECE] Embedded System Design
18CS3T15	[CSE] Internet Technology & Applications
18CS3T16	[CSE] Introduction to Machine Learning
18EI3T17	[EIE] Virtual Instrumentation
	Open Elective - IV
18BS3T18	[BSH] Simulation & Modeling
18BS3T19	[BSH] Power Plant Engineering
18BS3T20	[BSH] Entrepreneurship Development
18EC3T21	[ECE] Satellite Communication Systems
18EC3T22	[ECE] Robotics & Robot Applications
18CS3T23	[CSE] Big Data Analytics
18CS3T24	[CSE] Artificial Intelligence
18EI3T25	[EIE] Industrial Instrumentation

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

Type	Code	Power Systems Operation & Control	L-T-P	Credits	Marks
PC	18EE1T09		3-0-0	3	100

Objectives	The objective of this course is to study different aspects of power system operation and control of single area & interconnected systems, different load flow methods, economical operation of power systems, and methods for maintaining the frequency & voltage within permissible limits.
Pre-Requisites	Basic knowledge of Power system transmission and distribution, electrical machines and circuit 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	**Introduction to Power Systems**: Single Subscript Notation, Double Subscript Notation, Complex Power, The Power Triangle, Direction of Power Flow, Per-Unit System, Single Line diagram,Impedance and Reactance Diagram; **Admittance Matrix Formation**: Introduction to Graph Theory, Network Incidence Matrix, Branch & Node Admittances, Equivalent Admittance Network, Modification of YBUS.	**10 Hours**
Module-2	**Power Flow Solution**: The Power-Flow Problem, The Gauss-Seidal Method, The Newton-Raphson Method, De-coupled power flow, Power-Flow Studies in System Design and Operations.	**9 Hours**
Module-3	**Economic Operation of Power System**: Distribution of Load between Units within a Plant, Distribution of Load between Plants, The Transmission-Loss Equation, An interpretation of Transformation, Classical Economic Dispatch with Losses, Penalty Factor, Unit Commitment, Application of evolutionary computing to load dispatch.	**8 Hours**
Module-4	**ALFC of Single Area Systems**: Load Frequency Relation, Speed-Governing System, Hydraulic Valve Actuator, Turbine-Generator Response, Static Performance of Speed Governor, Closing the ALFC Loop, Concept of Control Area, Static & Dynamic Response of ALFC Loop, Physical Interpretation of Results, Secondary ALFC Loop, Economic Dispatch Control; **ALFC of Multi-Control-Area Systems**: Two Area Systems, Block Diagram Representation of Two Area System, Mechanical Analog of Two Area System, Control of Multi-area Systems.	**8 Hours**
Module-5	**Power System Stability**: The Stability Problem, Rotor Dynamics and the Swing Equation, Further Considerations of the Swing Equation, The Power-Angle Equation, Synchronizing Power Coefficient, Equal- Area Criterion for Stability, Further Applications of the Equal-Area Criterion, Multi-machine Stability Studies: Classical Representation.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. J. J. Grainger and W. D. Stevenson, ***Power System Analysis***, 1st Edition, McGraw-Hill Education, 2017.
T2. H. Sadaat, ***Power System Analysis***, McGraw-Hill Education, 2002.
T3. A. J. Wood and B. F. Wollenberg, ***Power Generation, Operation and Control***, 2nd Edition, John Wiley & Sons, 2006.

Reference Books:

R1. O. I. Elgerd, ***Electric Energy Systems Theory - An Introduction***, 2nd Edition, McGraw-Hill Education, 2017.
R2. I. J. Nagrath and D. P. Kothari, ***Modern Power System Analysis***, 4th Edition, Tata McGraw-Hill, 2011.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105067/: by Prof. A. K. Sinha, IIT Kharagpur
2. https://nptel.ac.in/courses/108/107/108107127/: by Dr. V. Pant & Dr. B. Das, IIT Roorkee

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

CO1	Formulate the admittance matrix and evaluate load, their behavior, and transmission line characteristics.
CO2	Solve power flow problem, determine the losses in the transmission system, and decide economic generation schedule at a snapshot.
CO3	Determine the economic operating schedule of generators.
CO4	Control change in power system dynamics with change in frequency in single and multi-area interconnected system.
CO5	Estimate the critical clearing time for stable power system operation and rotor angle stability analysis.

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.

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

Type	Code	Power System Protection	L-T-P	Credits	Marks
PC	18EE1T10		3-0-0	3	100

Objectives	The objective of this course is to study different aspects of power system protection, identify symmetrical/unsymmetrical fault conditions, calculate the fault current, breaking the circuit and limit the faulted zone.
Pre-Requisites	Basic knowledge of power system transmission & distribution, characteristics of different types of lines, and real & reactive power requirements is necessary.
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	**Faults**: Introduction, Causes & effects of faults, Zones of protection, Primary & backup protection, Desirable qualities of protective relaying, Connection of trip circuit. **Fault Analysis**: Symmetrical & unsymmetrical faults, LLL & LLL-G fault, Positive, negative and zero sequence components, Fault calculation, LG fault, LL & LLG fault, Short circuit analysis.	**8 Hours**
Module-2	**Relaying**: Classification of relays, Relay pick up, Reset or drop out, Pick up/ drop off ratio, Construction & working principles of electromagnetic relays, Theory of induction relay torque, General equation of electromagnetic & comparator relays. **Protection**: Over current protection - Fuse, Thermal relays (MCCB), Over current relay, Application of definite time and IDMT O.C. relay, Directional protection; Differential Protection - Behavior of simple differential protection, percentage differential protection, earth leakage protection; Distance Protection - Drawbacks of O.C. protection, Impedance, Reactance and MHO relay, Performance of distance relay during normal load and power swing, Three step protection.	**10 Hours**
Module-3	**Transformer Protection**: Types of faults, Over current protection, Percentage differential protection, Inrush phenomenon, High resistance ground faults, Inter-turn faults, Incipient faults. **Generator Protection**: Various faults & abnormal operation conditions, Stator & rotor faults, Transverse differential protection, Unbalanced loading, Over speeding, Loss of excitation, Loss of prime mover. **Induction Motor Protection**: Various faults & abnormal operation conditions, Starting of induction motor, Protection of small & large induction motor.	**9 Hours**

Cont'd...

Module-#	Topics	Hours
Module-4	**Circuit Breaking**: Fundamentals, Circuit breaker rating, Circuit constants & circuit conditions, Re-striking voltage transients, Characteristics of re-striking voltage, Interaction between the breaker & circuit, Current chopping, Duties of switchgear. **Conventional & Modern Circuit Breakers**: Automatic switch, Air-break circuit breakers, Oil circuit breakers, Air-blast circuit breakers, Modification of circuit breaker duty by shunt resistors, Power factor correction by series resistance, Comparative merits of different types of conventional circuit breakers, Modern trends, Vacuum circuit breakers, SF6 circuit breakers, auto-reclosing - definitions & features, 3-Phase vs. 1-Phase auto-reclosing.	**7 Hours**
Module-5	**Static Relays**: Comparators and different relays, Amplitude comparator, Phase comparator, Coincidence type phase comparator, Basic elements of a static relay, O.C. relays, Differential protection, Static distance protection. **Numerical Relays**: Block diagram, Numerical over-current protection, Numerical transformer differential protection, Numerical distance protection of transmission line. **Carrier Aided Protection of Transmission Lines**: Need, Options for carrier, Coupling and trapping the carrier into the desired line section, Single line to ground coupling, Line to Line coupling, Unit type carrier aided directional comparison relaying.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. Y. G. Parithankar and S. R. Bhide, ***Fundamentals Of Power System Protection***, 2nd Edition, PHI Learning, 2010.
T2. B Ravindranath and M Chander, ***Power System Protection and Switchgear***, 2nd Edition, New Age International, 2018.

Reference Books:

R1. A. G. Phadke and J. S. Thorp, ***Computer Relaying for Power Systems***, 2nd Edition, Wiley, 2012.
R2. S. S. Rao, ***Switchgear and Protection***, 1st Edition, Khanna Publishers, 2019.

Online Resources:

1. https://nptel.ac.in/courses/108/101/108101039/: by Prof. S. A. Soman, IIT Bombay

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

CO1	Apply symmetrical component to analyze different type of faults in power system.
CO2	Analyze various type of relay and their use cases in power system protection.
CO3	Estimate the requirement of protection for different equipment.
CO4	Describe the operation of different circuit breakers and obtain the type & rating of circuit breakers for protection.
CO5	Explore the modern trends in relaying for power system protection.

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.

Cont'd...

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

Type	Code	Introduction to VLSI Design	L-T-P	Credits	Marks
PE	18EI2T12		3-0-0	3	100

Objectives	The objective of this course is to study design of circuits and systems using integrated micro fabrication technologies and providing an overall state of art knowledge in the area of VLSI Design.
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 Process Flow – Basic Concepts, The CMOS n-Well Process, Layout Design Rules, Stick Diagrams and Layout of complex CMOS Logic Gates (Euler Method).	**8 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.	**8 Hours**
Module-3	**MOS Inverter Circuits**: Introduction, Voltage Transfer Characteristics, Noise Margin Definitions, CMOS Inverter, Sizing of 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.	**9 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, Power Dissipation in CMOS Gates, Power and Delay Tradeoffs.	**9 Hours**
Module-5	**Transfer Gate Logic Design**: Introduction, Basic Concepts of Pass Transistor, CMOS Transmission Gate Logic. **Basics of Semiconductor Memory**: DRAM, SRAM Cell Design & Operation, Memory Architecture.	**8 Hours**
	Total	**42 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	Explain the structure and operational analysis of MOSFET under external bias condition before and after scaling.
CO3	Design, implement and investigate Inverter, combinational and sequential logic circuits using CMOS technology.
CO4	Investigate switching characteristics of inverter to estimate its delay time and power consumption.
CO5	Design and analyze transmission gates, various memory cells, acquire the knowledge of different testing techniques and their reliability.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

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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.
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	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	2	1	1							1	2	1	2

Type	Code	Digital Image & Video Processing	L-T-P	Credits	Marks
PE	18EC2T13		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, Image Interpolation, 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, Adaptive filters, Linear position invariant degradations, Estimating the degradation function, inverse filtering, Wiener filter, Constrained least square filter. **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, Global processing using Hough transform, 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, Still image compression standards – JPEG and JPEG-2000.	**9 Hours**

Cont'd...

Module-#	Topics	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, Frame classification – I, P and B; Video sequence hierarchy – Group of pictures; Elements of a video encoder and decoder; Video coding standards – MPEG and H.26X. **Video Segmentation**: Temporal segmentation – Shot boundary detection, Hard and Soft-cuts; 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.

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	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	Soft Computing Techniques	L-T-P	Credits	Marks
PE	18EE2T14		3-0-0	3	100

Objectives	The objective of this course is to introduce the concepts of various soft computing techniques like fuzzy logic, neural networks etc., along with optimization techniques/evolutionary computation, and their applications in different fields of engineering.
Pre-Requisites	Knowledge of engineering mathematics and basics of 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 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, Neural Networks and Evolutionary Computing, Characteristics of Soft computing, Some applications of Soft computing techniques.	**6 Hours**
Module-2	**Fuzzy Logic Systems**: Basics of fuzzy logic theory, Crisp and fuzzy sets; 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.	**12 Hours**
Module-3	**Artificial Neural Networks**: Model of an artificial neuron, Neural network architectures, Single layer feedforward network, Multilayer feedforward network, Recurrent networks; Early neural network architectures - Rosenblatt's Perceptron, ADALINE network, MADALINE network, Examples & applications of neural networks.	**7 Hours**
Module-4	**Training of ANN**: Generalized delta rule, Hebbian rule; Back propagation algorithm, Effect of tuning parameters of the backpropagation 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**: Biological evolution and its application to search techniques, Concept of Genetics, GA architectures, GA operators - Encoding, Crossover, Selection, Mutation, Solving of single-objective optimization problems using GAs; Introduction to other optimization techniques and hybrid evolutionary algorithms.	**7 Hours**
	Total	**42 Hours**

P.T.O

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/: by Prof. D. Samanta, IIT Kharagpur
3. https://nptel.ac.in/courses/117/105/117105084/: by 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	2	2	1	2	1								1	1	
CO2	3	3	2	2	2							1	2	2	2
CO3	2	1	2	1	2							1	2	2	2
CO4	3	3	2	2	2							1	2	2	2
CO5	2	2	2	2	2							1	1	2	2

Type	Code	Flexible AC Transmission Systems	L-T-P	Credits	Marks
PE	18EE2T15		3-0-0	3	100

Objectives	The objective of this course is to study the reactive power control techniques, shunt & series compensation, static VAR compensators and their applications, including Thyristor controlled series capacitors, STATCOM devices, and FACTS controllers.
Pre-Requisites	Knowledge of Power Electronics and Power 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	FACTS Concept & General System Considerations: Power Flow and Dynamic Stability Considerations of a Transmission Interconnection, Relative Importance of Controllable Parameters, Basic Types of FACTS Controllers, Basic Description and Definitions of FACTS Controllers.	**6 Hours**
Module-2	Static Shunt Compensation: Objectives of Shunt Compensation, Methods of Controllable VAR Generation, Static VAR Compensators, SVC and STATCOM.	**11 Hours**
Module-3	Static Series Compensators: Objective of Series Compensation, TSSC, TCSC, Variable Impedance Type Series Compensators, Switching Converter Type Series Compensators (SSSC).	**11 Hours**
Module-4	Static Voltage and Phase Angle Regulators: Objectives of Voltage and Phase Angle Regulators, Approaches to Thyristor Controlled Voltage and Phase Angle Regulators: TCVR and TCPAR.	**10 Hours**
Module-5	Combined Compensators: Introduction, Unified Power Flow Controller (UPFC), Interline Power Flow Controller (IPFC).	**4 Hours**
	Total	**42 Hours**

Text Books:

T1. N. G. Hingorani and L. Gyugyi, ***Understanding FACTS: Concepts & Technology of Flexible AC Transmission Systems***, 2nd Edition, IEEE Press, Standard Publishers Distributors, 2004.

Reference Books:

R1. K. R. Padiyar, ***Facts Controllers in Power Transmission and Distribution***, 2nd Edition, New Age International, 2016.
R2. E. Acha, C. F. Esquivel, H. A. Pérez, and C. A. Camacho, ***Modelling & Simulation in Power Networks***, 1st Edition, Wiley India, 2012.

Online Resources:

1. https://nptel.ac.in/courses/108107114/: by Prof. A. Bhattacharya, IIT Roorkee

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

CO1	Illustrate the concept of dynamic stability of transmission line and relative controllable parameters.
CO2	Analyze the static shunt compensation methods and study the working of SVC and STATCOM.
CO3	Learn the working of TSSC, TCSC, Variable Impedance Type Series Compensators and Switching Converter Type Series Compensators (SSSC) for series compensation.
CO4	Develop understanding of the concepts and methods of voltage and phase angle regulation and use of TCPAR and TCVR for voltage and phase angle regulation.
CO5	Interpretthe working of different combined compensators for series and shunt compensation using IPFC & UPFC.

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

Type	Code	Digital Communication	L-T-P	Credits	Marks
PE	18EC2T16		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.

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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	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	Microwave Engineering	L-T-P	Credits	Marks
PE	18EC2T17		3-0-0	3	100

Objectives	The objective of this course is to study microwaves, their frequency bands, microwave tubes, amplifiers, components, microwave solid state devices, principles of radar, and scanning & tracking techniques.
Pre-Requisites	Basic knowledge of Circuit Theory, Electromagnetic Theory, and Solid State Physics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

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

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Microwave Tubes**: Introduction, frequency bands, applications, Conventional tubes - vacuum diode, triode, tetrode, pentode; Limitations of conventional tubes, Reflex Klystron - construction, operation, velocity modulation, power output, efficiency, electronic admittance, Magnetron - construction, operation, cyclotron angular frequency, resonant modes, Hull's cutoff magnetic flux density & cutoff voltage.	**9 Hours**
Module-2	**Microwave Amplifiers**: Klystron Amplifier - construction, operation, reentrant cavities, velocity modulation, output power, beam loading, efficiency, mutual conductance, Travelling Wave Tube (TWT) - Slow wave structures, construction, amplification process.	**8 Hours**
Module-3	**Microwave Components**: Analysis using s-parameters, Junctions (E-Plane, H-Plane, Magic Tee), Directional coupler; Bends and corners; Microwave posts, S. S. tuners, Attenuators, Phase shifter, Ferrite devices (Isolator, Circulator, Gyrator); Cavity resonator.	**8 Hours**
Module-4	**Radar Systems**: Principles & operation; Range equation; Pulse repetition frequency (PRF) & range ambiguities; Doppler Radars - Determination of velocity, Continuous Wave (CW) radar and its limitations, Frequency Modulated Continuous Wave (FMCW) radar, Moving Target Indicator (MTI) radar, Delay line cancellers, Blind speeds & staggered PRFs; Scanning & Tracking - horizontal, vertical, spiral, palmer, raster, nodding; Angle tracking systems - Lobe switching, Conical scan, Mono pulse.	**9 Hours**
Module-5	**Microwave Solid State Devices**: Limitations of conventional solid state devices at microwaves; Transistors, Diodes (Tunnel, Varactor, PIN), Transferred electron devices (Gunn diode); Avalanche transit time effect (IMPATT, TRAPATT, SBD); Microwave Amplification by Stimulated Emission of Radiation (MASER).	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. D. M. Pozar, ***Microwave Engineering***, 4th Edition, Wiley Publications, 2011.

T2. S. Liao, ***Microwave Devices and Circuits***, 3rd Edition, Pearson Education, 2006.
T3. M. I. Skolnik, ***Introduction to Radar Systems***, 3rd Edition, McGraw-Hill Education, 2001.

Reference Books:

R1. G. S. Rao, ***Microwave and Radar Engineering***, 1st Edition, Pearson Education, 2014.
R2. R. E. Collin, ***Foundation of Microwave Engineering***, 2nd Edition, John Wiley & Sons, 2007.
R3. M. Kulkarni, ***Microwave Devices and Radar Engineering***, 5th Edition, Umesh Publications, 2014.

Online Resources:

1. https://nptel.ac.in/courses/108/101/108101112/: by Prof. G. Kumar, IIT Bombay
2. https://nptel.ac.in/courses/108/103/108103141/: by Prof. R. Bhattacharjee, IIT Guwahati
3. https://nptel.ac.in/courses/117/105/117105138/: by Prof. A. Bhattacharya, IIT Kharagpur
4. https://nptel.ac.in/courses/117/105/117105130/: by Prof. A. Bhattacharya, IIT Kharagpur
5. https://nptel.ac.in/courses/117/105/117105122/: by Prof. A. Bhattacharya, IIT Kharagpur
6. https://nptel.ac.in/courses/117/101/117101119/: by Prof. J. Mukherjee, IIT Bombay

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

CO1	Describe conventional vacuum tubes, their limitations, microwaves, and their sources.
CO2	Explain the principle of operation of various microwave amplifiers.
CO3	Identify, describe, and explain different microwave components.
CO4	Explain the basic principle of Radar, various scanning and tracking techniques.
CO5	Understand the principle of microwave generation using solid state devices.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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

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

Type	Code	Power Quality	L-T-P	Credits	Marks
PE	18EE2T18		3-0-0	3	100

Objectives	The objective of this course is to introduce various power quality problems observed in a power system, their sources & causes, and modern methods to improve the overall quality of electrical power.
Pre-Requisites	Basic knowledge of mathematics and power system transmission & distribution 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 Quality**: Introduction, Terms and definitions, Overloading - Under voltage, Over voltage, Transients - Short duration, Long duration, Sags & swells - Voltage sag, swell, imbalance, fluctuation, Frequency variations; International standards of power quality, CBEMA curve; Voltage Sags and Interruptions: Sources, Estimating voltage sag performance, Thevenin's equivalent source, Analysis & calculation of various faulted conditions, Voltages sag due to induction motor starting, Estimation of sag severity, Mitigation of voltage sags, Active series compensators, Static & fast transfer switches.	**10 Hours**
Module-2	**Overvoltages**: Sources - Capacitor switching, Lightning, Ferro-resonance, Mitigation of voltage swells - Surge arresters, Low pass filters, Power conditioners, Lightning protection – Shielding, Line arresters, protection of transformers & cables; Computer analysis tools for transients, PSCAD and EMTP.	**7 Hours**
Module-3	**Harmonics**: Harmonic sources from commercial & industrial loads, Locating harmonic sources, Power system response characteristics - Harmonics vs. transients, Effect of harmonics – Harmonic distortion, Voltage & current distortion, Harmonic indices, Inter-harmonics resonance, Harmonic distortion evaluation - Devices for controlling harmonic distortion, Passive & active filters, IEEE and IEC standards.	**7 Hours**
Module-4	**Power Quality Monitoring**: Monitoring considerations, Monitoring and diagnostic techniques for various power quality problems, Modelling of power quality (harmonics and voltage sag) problems by mathematical simulation tools, Power line disturbance analyzer, Quality measurement equipment, Harmonic/ spectrum analyzer, Flicker meters, Disturbance analyzer, Applications of expert systems for power quality monitoring.	**8 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	**DSTATCOM & UPQC**: Reactive Power Compensation, Harmonics and unbalance mitigation in distribution systems using DSTATCOM and shunt active filters, Synchronous reference frame extraction of reference currents, Current control techniques for DSTATCOM; Voltage Sag/Swell Mitigation: Dynamic voltage restorer, Working principle and control strategies; Series Active Filtering; Unified Power Quality Conditioner (UPQC): Working principle, capabilities and control strategies.	**10 Hours**
	Total	**42 Hours**

Text Books:

T1. R. C. Dugan, M. F. McGranaghan, S. Santoso, and H. W. Beaty, ***Electrical Power Systems Quality***, 3rd Edition, McGraw-Hill, 2017.
T2. J. Arrillaga, N. R. Watson, and S. Chen, ***Power Systems Quality Assessment***, 1st Edition, John Wiley & Sons, 2011.
T3. C. Sankaran, ***Power Quality***, 1st Edition, CRC Press, 2001.
T4. M. H. Bollen, ***Understanding Power Quality Problems***, 1st Edition, Wiley India, 2011.

Reference Books:

R1. G. T. Heydt, ***Electric Power Quality***, 2nd Edition, West Lafayette, 1994.
R2. G. J. Wakileh, ***Power Systems Harmonics – Fundamentals, Analysis and Filter Design***, 1st Edition, Springer, 2007.
R3. E. Aeha and M. Madrigal, ***Power System Harmonics: Computer Modelling and Analysis***, 1st Edition, Wiley India, 2012.
R4. R. S. Vedam and M. S. Sarma, ***Power Quality: VAR Compensation in Power Systems***, 1st Edition, CRC Press, 2013.

Online Resources:

1. https://nptel.ac.in/courses/108/107/108107157/: by Prof. A. Bhattacharya, IIT Roorkee
2. https://nptel.ac.in/courses/108/106/108106025/: by Dr. M. Kumar, IIT Madras

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

CO1	Identify the power quality issues in electrical distribution network and classify power quality problems.
CO2	Evaluate the severity of overvoltage in a power system and identify suitable method to overcome the effect.
CO3	Estimate the effect of harmonics on power quality.
CO4	Develop monitoring techniques for power quality issues.
CO5	Design power electronics circuits to mitigate power quality issues.

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

Type	Code	Smart Grid	L-T-P	Credits	Marks
PE	18EE2T19		3-0-0	3	100

Objectives	The objective of the course is to study concepts of smart grid, smart metering, problems associated with integration of distributed generation and their solution through smart grid, and evolution of microgrids and their operation.
Pre-Requisites	Basic knowledge of conventional grids, renewable energy systems, power electronics converters, and basics of communication 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 current trends of smart grid.

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**: Evolution of Electric Grid, Basic concepts of Grid, Need for Smart Grid, Standard concepts & definitions of Smart Grid, Functions, Opportunities, Challenges & benefits, Comparison between conventional and Smart Grid. **Smart Grid Components**: Smart infrastructure, Communication, Management & protection, Initiatives in Smart Grid.	**8 Hours**
Module-2	**Architecture & Standards**: Types of domains in architecture, Standards in Distributed Energy Resources (DERs), Wide Area Situation Awareness, Protection & automation, Time synchronization, Cyber Security. **Elements & Technologies**: Smart metering, Advanced Metering Infrastructure (AMI), Distribution Automation (DA), SCADA System, Outage Management System (OMS), Plug-in Hybrid Electric Vehicle (PHEV), Vehicle-to-Grid (V2G). **Communications Infrastructure & Protocols**: WAN, NAN, and HAN, Types of communication technologies - Ethernet, Wireless LANs, Bluetooth, ZigBee, WiMax, and Broadband over Power Line (BPL).	**10 Hours**
Module-3	**Distributed Energy Resources (DERs)**: Types, Working, Advantages and disadvantages of solar PV system, Solar thermal, Biomass, Wind, Fuel cell, Micro turbine. **Energy Storage Technologies**: Mechanical, Electrical, Electromagnetic, Electrochemical (Battery Energy Storage System (BESS)), Thermal.	**8 Hours**
Module-4	**Wide Area Measurement System (WAMs)**: Phasor estimation, Phasor Measurement Units (PMU) – Synchro phasor, PMU device, Operation. **Smart Sensors**: Intelligent Electronic Devices (IEDs), Geographic Information Systems (GIS), Basics of Demand Side Management (DSM).	**8 Hours**
Module-5	**Microgrid**: Introduction, Definitions, Types of Microgrids, Modes of operation, Introduction to Microgrid control & protection, Structure of AC and DC Microgrid, Challenges in Microgrid, Value addition of Microgrid.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Ekanayake, N. Jenkins, K. Liyanage, J. Wu, and A. Yokoyama, ***Smart Grid: Technology and Applications***, Student Edition, Wiley, 2012.
T2. C. W. Gellings, ***The Smart Grid: Enabling Energy Efficiency and Demand Response***, 1st Edition, CRC Press, 2009.

Reference Books:

R1. S. Borlase, ***Smart Grid: Infrastructure, Technology and Solutions***, 1st Edition, CRC Press, 2012.
R2. A. G. Phadke and J. S. Thorp, ***Synchronized Phasor Measurement and their Applications***, Springer, 2008.
R3. J. A. Momoh, ***Smart Grid: Fundamentals of Design and Analysis***, 1st Edition, Wiley-IEEE Press, 2012.
R4. P. F. Schewe, ***The Grid: A Journey through the Heart of our Electrified World***, Joseph Henry Press, 2007.
R5. S. K. Salman, ***Introduction to the Smart Grid: Concepts, Technologies and Evolution***, IET, 2017.

Online Resources:

1. https://www.smartgrid.gov/
2. http://www.nsgm.gov.in/
3. https://smartgrid.ieee.org/
4. https://nptel.ac.in/courses/108/107/108107113/

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

CO1	Visualize the architecture of Smart grid and its differences from a conventional grid.
CO2	Apply smart metering concepts to industrial and commercial installations and find smart grid solutions using modern communication technologies.
CO3	Formulate solutions in the areas of smart substations, distributed generation and energy storage technologies.
CO4	Explore types of smart sensors and more about wide area measurement systems.
CO5	Gain insight about the evolution of Microgrids, their types and operation.

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

Type	Code	Stochastic Processes	L-T-P	Credits	Marks
OE	18BS3T12		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	18BS3T13		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	Project Systems Management: a life cycle approach, project characteristics; Project life cycle phases - conception, definition, planning and organizing, implementation, clean up; Project feasibility analysis - market, technical, financial; The project manager: roles & responsibilities, team building and conflict management; Tools and techniques for project management; Environmental impact analysis of a project.	**9 Hours**
Module-2	Commonly used techniques for Project Management, Network techniques - PERT, CPM and GERT; Project appraisal criteria - NPV, IRR; Pay back period, sensitivity analysis; Line of Balance (LOB), Accounting for risk, uncertainty and fuzziness. Time cost trade-offs and crashing procedures; Multi project planning & scheduling with limited resources; Multi objective, fuzzy and stochastic based formulations in a project environment.	**9 Hours**
Module-3	Project Resource Management: Allocation, Leveling and Smoothing methods; Multi project and multi resource, multi-mode scheduling under various constraints - limited resources, limited budget, non-split, start/end lag; Application of Heuristics.	**8 Hours**
Module-4	Cost Benefit Analysis: Cost benefit analysis – projects procurement process, life cycle costing, project cost reduction methods, project stores; Project Cost: Dynamics of project cost, Estimation of capital cost, Estimating operating costs, Forecasting income, Financial sources, Role of development financial institutions; Social cost benefit analysis.	**8 Hours**
Module-5	Planning, Monitoring and Control: Design of monitoring system, Computerized PMIS (Project Management Information System); Funds planning, performance budgeting and control; Project materials management; Pricing, estimating, and Contract Administration & Management, Building & Bid evaluation and analysis.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. R. Paneerselvam and P. Senthilkumar, ***Project Management***, 1st Edition, PHI Learning, 2009.

T2. B. Punmia and K. Khandelwal, ***Project Planning and Control with PERT and CPM***, 4th Edition, Laxmi Publications, 2006.

Reference Books:

R1. P. Chandra, ***Projects Planning, Analysis, Selection, Financing, Implementation and Review***, 9th Edition, McGraw Hill Education, 2019.
R2. C. Gray, E. Larson, and G. Desai, ***Project Management The Managerial Process***, 7th Edition, McGraw Hill, 2013.

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	Preform 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:

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

Type	Code	Embedded System Design	L-T-P	Credits	Marks
OE	18EC3T14		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	Internet Technology & Applications	L-T-P	Credits	Marks
OE	18CS3T15		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	Introduction to Machine Learning	L-T-P	Credits	Marks
OE	18CS3T16		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	Virtual Instrumentation	L-T-P	Credits	Marks
OE	18EI3T17		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	Fundamentals of Management	L-T-P	Credits	Marks
HS	18HS1T03		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	Mobile Communication & Networks	L-T-P	Credits	Marks
PE	18EC2T20		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. 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	Use internet from remote location for multiple access signal structuring.
CO5	Multiplex higher layer protocols and design wi-fi infrastrcture.

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	PLC & SCADA	L-T-P	Credits	Marks
PE	18EE2T21		3-0-0	3	100

Objectives	The objective of this course is to study programming & applications of Programmable Logic Controllers (PLC), data acquisition systems, SCADA systems, and their applications in power systems.
Pre-Requisites	Knowledge of programming, control systems, and power 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	**Programmable Logic Controllers (PLCs)**: Introduction, Block diagram, PLC operations, Comparison with relays circuit, Basic instructions, Examples, Level control application, Latch instructions, Counters, Timers, Shift registers; PLC Hardware Components: The I/O section, Discrete I/O modules, Analog I/O modules, Special I/O modules, I/O specifications, The CPU, Memory design, Memory types, Programming devices, Selection of wire types and size.	**8 Hours**
Module-2	**Fundamentals of Logic**: Hardwired logic vs. programmed logic, Ladder diagram, Functional block diagram, Instruction list, Structured text, Common elements of programming languages, Variables and data types, Functions, Function blocks, Timers - ON, OFF, PULSE, Counters - increment, decrement; Introduction to Ladder logic; Programming word level logic instructions; Converting relay schematics and boolean equation into PLC ladder programs.	**10 Hours**
Module-3	**I/O Devices & Interfacing with PLC**: Types of input devices, Switches - Push button switches, Toggle Switches, Proximity switches, Temperature switch, Pressure switch, Level switch, Flow switches, Motor starters, Transducers and sensors, Transmitters etc. Types of output devices - Electromagnetic control relays, Latching relays, Contactors, Motors, Pumps, Solenoid valves etc.	**9 Hours**
Module-4	**SCADA**: Need of SCADA system, Distributed control Systems (DCS), General definition and SCADA components; Hardware architecture, Software architecture, Protocol detail, Discrete and analog control; Interfacing PLC with SCADA; PLCs vs. RTUs, RTU block diagram, MTU communication interface, Future trends, Internet based SCADA display system, Components of control systems in SCADA.	**9 Hours**
Module-5	**SCADA in Power Systems**: Main task in power systems - Planning, Operation, Accounting, Tasks of National & Regional control centres, Generating station control room, AGC-SCADA, SCADA in generation, power distribution, and power grid.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Bhanot, ***Process Control: Principles and Applications***, 1st Edition, Oxford University Press, 2011.
T2. D. Patranabis, ***Principles of Process Control***, 6th Reprint, McGraw-Hill Education, 2012.
T3. M. Mitra and S. S. Gupta, ***PLC and Industrial Application***, 2nd Edition, Penram International, 2017.
T4. S. A. Boyer, ***SCADA - Supervisory Control and Data Acquisition***, Instrument Society of America, 2004.

Reference Books:

R1. F. D. Petrusella, ***Programmable Logic Controller***, 4th Edition, Tata McGraw-Hill, 2017.
R2. R. Mishra and V. Vij, ***PLC & SCADA - Theory and Practice***, 1st Edition, Laxmi Publications, 2011.
R3. M. S. Thomas and J. D. McDonald, ***Power System - SCADA and Smart Grids***, 1st Edition, CRC Press, 2015.
R4. J. W. Webb and R. A. Reis, ***Programmable Logic Controllers: Principles and Applications***, 5th Edition, PHI Learning, 2009.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105062/: by Prof. S. Sen & Prof. S. Mukhopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/108/106/108106022/: by Dr. K. S. Swarup, IIT Madras
3. http://www.plcmanual.com/

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

CO1	Describe the fundamentals of PLC and its hardware components.
CO2	Apply basic programming concepts and various logical instructions of PLC in industrial applications.
CO3	Interface different types of I/O devices with PLC as per application requirements.
CO4	Integrate SCADA with PLC with proper interfacing for creating industrial control systems.
CO5	Explore applications of SCADA for automation of 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.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

P.T.O

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

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

Type	Code	High Voltage Engineering	L-T-P	Credits	Marks
PE	18EE2T22		3-0-0	3	100

Objectives	The objective of the course is to study the basic concepts and recent trends in the field of high voltage engineering, high voltage testing of various insulators and determination of their dielectric strengths.
Pre-Requisites	Basic knowledge of chemistry, material science & power 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	**Electrostatic fields and field stress control**: Electrical field distribution and breakdown strength of insulating materials - fields in homogeneous, multi-dielectric materials, isotropic materials. **Electrical breakdown in gases**: Gases as insulating media, Ionization and decay processes, Townsend's first & second ionization coefficients, Secondary electron emission by photon impact; Transition from non-self-sustained discharges to breakdown: Streamer mechanism of spark, Sparking voltage – Paschen's law, Breakdown in non-uniform fields - Partial breakdown, Corona discharges.	**12 Hours**
Module-2	**Breakdown in liquid and solid dielectrics**: Liquid as insulators, Breakdown in liquids - Electronic breakdown, Suspended solid particle mechanism, Cavity breakdown, Static electrification in power transformers, Transformer oil filtration & test, Alternative liquid insulations; Breakdown in solids - Intrinsic, Streamer, Electromechanical, Edge, Thermal, Erosion; Tracking & Treeing; Breakdown of solid dielectrics in practice, Partial discharges in solid insulation.	**6 Hours**
Module-3	**Generation of high voltages**: Direct voltages, Half and full wave rectifier circuits, Voltage multiplier circuits, Van de Graff generators, Electrostatic generators, Alternating voltages, Impulse voltages, Standard lightning & switching surge, Design & construction of impulse generator circuits, Marx circuit operation, Lightning mechanism; Insulation coordination - Insulation level, Statistical approach, Correlation between insulation & protection levels.	**10 Hours**
Module-4	**Measurement of high voltages**: High direct voltage measurement, Electrostatic voltmeters, Peak voltage measurements by spark gaps, Sphere gaps, Reference measuring systems, Uniform field gaps, Rod gaps, Generating voltmeters & field sensors, High- voltage capacitors for measuring circuits - Voltage dividing systems & impulse voltage measurements, Digital recorders and inherent errors.	**8 Hours**

Cont'd...

Module-#	Topics	Hours
Module-5	**High voltage testing**: Testing of insulators, Bushings, Isolators, Circuit breakers, Cables, Transformers, Surge diverters, Radio interference measurements, Design, planning and layout of high voltage laboratory.	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. M. S. Naidu and V. Kamaraju, ***High Voltage Engineering***, 5th Edition, McGraw-Hill Education, 2017.

Reference Books:

R1. E. Kuffel. W. S Zaengel, and J. Kuffel, ***High Voltage Engineering Fundamentals***, Newnes (Elsevier), 2008.

R2. C. L. Wadhwa, ***High Voltage Engineering***, 3rd Edition, New Age International, 2015.

Online Resources:

1. https://nptel.ac.in/courses/108/104/108104048/

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

CO1	Comprehend the concepts of break down phenomena in gas as a dielectric.
CO2	Provide deep insight on the break down phenomena in solid and liquid as dielectrics.
CO3	Design and analysis of various circuits for generation of high voltage & high currents.
CO4	Analyze various measurement methods of high voltage and high currents.
CO5	Perform testing of high voltage circuits using various high voltage electrical apparatus.

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

Type	Code	Simulation & Modelling	L-T-P	Credits	Marks
OE	18BS3T18		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	Power Plant Engineering	L-T-P	Credits	Marks
OE	18BS3T19		3-0-0	3	100

Objectives	The objective of this course is to impart a basic understanding of the different types of power plants, site selection criteria, cooling tower operations etc., and basics of hydroelectric, diesel, and nuclear power generation.
Pre-Requisites	Basic knowledge of thermodynamics, fluid mechanics, environmental sciences and engineering chemistry 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**: Power plant and Power cycles, Energy sources for generation of electric power, Types of power plants, Special features and applications, Selection of Power plant, Fossil fuel power plant and its application.	**7 Hours**
Module-2	**Hydroelectric Power**: Potential power with reference to rainfall and catchments area, Water storage, Equipment used in hydroelectric power stations. Characteristics of hydraulic turbines; Introduction to Steam Flow through nozzles, Steam Turbines, Types of nozzles, Isentropic flow through nozzles, Effect of friction, Nozzle efficiency, Critical Pressure ratio and maximum discharge, Throat and exit area, Classification of turbines, Governing and control of turbines.	**10 Hours**
Module-3	**Steam Power**: Steam power plant cycles - Rankine cycle, Modified Rankine cycles, Reheat cycles, Regenerative cycles, General layout of modern steam power plant, Pollution control equipment, High pressure boilers, Super heater and air preheater, Fluidized bed boilers, Fuel and ash handling equipment, Water treatment plant, Spray ponds and cooling towers, Steam condenser type and calculation.	**9 Hours**
Module-4	**Nuclear Power**: Classifications and essential component of nuclear reactors, Heavy water moderator and cooled reactors, CANDU reactors, Light water reactor, Gas cooled reactors, Liquid metal cooled reactors, Disposal of nuclear waste.	**8 Hours**
Module-5	**Non-conventional Power**: Brief discussion on Solar power plants, Wind power plants, Tidal energy power plants, Geothermal power plants, Biomass power plant, Comparison of the factors governing the cost of all power plants.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. P. K. Nag, ***Power Plant Engineering***, 2nd Edition, Tata McGraw-Hill, 2019.
T2. M. M. El-Wakil, ***Power Plant Technology***, 2nd Edition, Tata McGraw-Hill, 2010.
T3. B. H. Khan, ***Non-conventional Energy Resources***, 2nd Edition, Tata McGraw-Hill, 2009.

Reference Books:

R1. S. Domkundwar and C. Arora, ***Power Plant Technology***, 6th Edition, Dhanapat Rai & Sons, 2011.
R2. M. Verma, ***Power Plant Engineering***, 3rd Edition, Metropolitan Book Company, 1976.

Online Resources:

1. https://nptel.ac.in/courses/112/107/112107216/: by Prof. R. Kumar, IIT Roorkee
2. https://nptel.ac.in/courses/112/103/112103277/: by Dr. V. Kulkarni, IIT Guwahati
3. https://nptel.ac.in/courses/127/106/127106135/: Prof. T. N. C. Anand, IIT Madras
4. https://www3.nd.edu/~powers/ame.20231/notes.pdf

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

CO1	Evaluate the criteria for power plant layout and site selection, understand the concepts of power cycles, sources of energy and fossil fuel power plants.
CO2	Describe the concepts of the hydroelectricity generation and explain the working principle of various components of hydro & steam power plants.
CO3	Analyze the principle of steam turbines, nozzles, and their industrial applications.
CO4	Explain the principles and working of nuclear power plants.
CO5	Evaluate the performances of various power plants based on conventional and non-conventional sources of energy.

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

Type	Code	Entrepreneurship Development	L-T-P	Credits	Marks
OE	18BS3T20		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 and Overview: Concept of Entrepreneurship, The Entrepreneurial Process, Entrepreneurial Motivation, Developing Entrepreneurial Competencies, Characteristics of successful entrepreneur, Role of Entrepreneurship in Economic Development, Evolution and Growth of entrepreneurship in India.	**8 Hours**
Module-2	Ideas, Creativity, Innovation, Markets and Entrepreneurship: 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 of business plan, Formulation of business plan, Presentation of business plan to the investors, Techno-economic feasibility Assessment: A preliminary Project Report, The Detailed Project Report, Project Appraisal, Methods of Project Appraisal	**9 Hours**
Module-4	Financial Plan, and Marketing and Human Resource Management: Creating a successful financial plan, Source of financing, Institutional Finance to entrepreneurs, Basic financial statements, Ratio Analysis, Break-even Analysis. Problems of HRM and Relevant Labour laws, Marketing Management of Enterprises, Institutional support to entrepreneurs in Marketing.	**9 Hours**
Module-5	Intellectual Property: Concept and importance of Intellectual Property, Patents, Trade Mark, Copy rights, Trade secrets, Intellectual property audit, Start up: The Concept, Start up Policy of Government of India and Odisha in MSME sectors, Problems of MSME Sector, Sickness in MSMEs, Government 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. S. S. Khanka, ***Entrepreneurial Development***, 4th Edition, S. Chand & Co., 2010.

T3. Z. Thomas and S. Norman, ***Essentials of Entrepreneurship and Small Business Management***, 5th Edition, PHI Learning, 2009.

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	Satellite Communication Systems	L-T-P	Credits	Marks
OE	18EC3T21		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	Robotics & Robot Applications	L-T-P	Credits	Marks
OE	18EC3T22		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	Big Data Analytics	L-T-P	Credits	Marks
OE	18CS3T23		3-0-0	3	100

Objectives	The objective of the course is to study different techniques to find similar items, mining data streams, link analysis, clustering techniques, recommendation systems, and collaborative filtering used for Big Data, along with the concepts of batch processing, Hadoop, MapReduce & Spark.
Pre-Requisites	Knowledge of basics of data mining & algorithm design 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 to Big Data, Data Management for Big Data, Data Exploration and Reproducibility, Data Quality; Introduction to Map Reduce, Map Reduce algorithm, patterns & relations, Parallel databases vs. Map Reduce, Storage solutions.	**7 Hours**
Module-2	Big Data Algorithms-I: Nearest Neighbor Search, Shingling of Documents, Similarity Preserving Summaries of Sets, Locality Sensitive Hashing for Documents, Distance Measures, Theory of Locality Sensitive Functions, LSH Families for High Degree of Similarities.	**9 Hours**
Module-3	Big Data Algorithms-II: Streaming Data Models, Sampling Data in a Stream, Filtering Streams, Counting Distinct Elements in a Stream, Estimating Moments, Counting Ones in Window, Page Rank, Efficient Computation of Page Rank, Topic Sensitive Page Rank.	**9 Hours**
Module-4	Big Data Algorithms-III: Clustering Techniques - BFR Algorithm, CURE Algorithm, Clustering in Non-Euclidean Space, Clustering for Streams and Parallelism; Matrix Factorization, Recommendation Systems and Collaborative Filtering.	**9 Hours**
Module-5	Introductions to Spark, Hadoop, Hive, Pig-Latin, Large Scale Visualization.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Leskovec, A. Rajaraman, and J. D. Ullman, ***Mining of Massive Datasets***, 2nd Edition, Cambridge University Press, 2014.
T2. J. Bell, ***Machine Learning for Big Data: Hands-On for Developers and Technical Professionals***, Wiley, 2014.

Reference Books:

R1. J. Han, M. Kamber, and J. Pei, ***Data Mining Concepts and Techniques***, 3rd Edition, Morgan Kaufman Publications, 2011.
R2. T. M. Mitchell, ***Machine Learning***, 1st Edition, McGraw-Hill Education, 2017.

Online Resources:

1. https://nptel.ac.in/courses/106/106/106106142/: by Prof. J. Augustine, IIT Madras
2. https://nptel.ac.in/courses/106/104/106104189/: by Dr. R. Misra, IIT Patna
3. http://www.mmds.org: Material on Mining of Massive Data Sets
4. http://lintool.github.com/MapReduceAlgorithms/index.html

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

CO1	Explain the concepts of Big Data and Map Reduce techniques.
CO2	Apply different tools and techniques used for finding similar items.
CO3	Demonstrate application of algorithms for analysis of streaming data and link analysis.
CO4	Apply different techniques for recommendation systems & collaborative filtering and compare different clustering techniques to apply them for large dataset.
CO5	Explore the concepts of Hadoop, MapReduce, Spark and apply them to implement big data algorithms.

Program Outcomes Relevant to the Course:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO12	**Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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

Type	Code	Artificial Intelligence	L-T-P	Credits	Marks
OE	18CS3T24		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	Industrial Instrumentation	L-T-P	Credits	Marks
OE	18EI3T25		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 Instrumentation and Control***, 4th Edition, PHI Learning, 2012.
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	Power Systems Lab	L-T-P	Credits	Marks
PC	18EE1L09		0-0-2	1	100

Objectives	The objective of this laboratory course is to practically investigate the operational principles, calculate different components of equipment & line flows, and use software analysis for problem solving in power systems.
Pre-Requisites	Basic knowledge of power system transmission & distribution, characteristics of different types of lines, and real & reactive power requirements is necessary.
Teaching Scheme	Regular laboratory experiments should be conducted under supervision of the teacher. Demonstration and necessary safety measures will be explained for each experiment in the pre-lab sessions.

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	Comparative study of short, medium, and long transmission lines with the given resistance inductance and capacitance of the transmission line.
2	Formation of Ybus matrix from line data using MATLAB.
3	Solving power flow of a network using MATLAB.
4	Solving Economic load dispatch using MATLAB
5	Automatic load frequency control of single area system using Simulink.
6	Automatic load frequency control of multi-area system using Simulink.
7	Determination of negative and zero sequence synchronous reactance of an alternator.
8	Determination of sub-transient direct axis and quadrature axis synchronous reactance of a 3-phase salient pole alternator.
9	Study of over current and 3-phase differential relay.
10	Study of series and shunt compensation. Study of Ferranti effect, voltage profile and determination of ABCD parameters of HV transmission line.

Text Books:

T1. J. J. Grainger and W. D. Stevenson, ***Power System Analysis***, 1st Edition, McGraw-Hill Education, 2017.
T2. H. Sadaat, ***Power System Analysis***, McGraw-Hill Education, 2002.
T3. A. J. Wood and B. F. Wollenberg, ***Power Generation, Operation and Control***, 2nd Edition, John Wiley & Sons, 2006.

Reference Books:

R1. O. I. Elgerd, ***Electric Energy Systems Theory - An Introduction***, 2nd Edition, McGraw-Hill Education, 2017.
R2. I. J. Nagrath and D. P. Kothari, ***Modern Power System Analysis***, 4th Edition, McGraw-Hill Education, 2011.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105067/: by Prof. A. K. Sinha, IIT Kharagpur
2. https://nptel.ac.in/courses/108/107/108107127/: by Dr. V. Pant & Dr. B. Das, IIT Roorkee

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

CO1	Explain the characteristics of long short and medium transmission line.
CO2	Analyze power flow through any line in a steady state condition.
CO3	Determine optimal utilization of resources distributed through the system.
CO4	Simulate different types of frequency control mechanisms.
CO5	Analyze different components of equipment and line flows in the 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.
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.

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