ACADEMIC CURRICULA

UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

(With exit option of Diploma)

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 15
(Syllabi for Electrical and Electronics Engineering & Electric Vehicle Technology Programme Courses)

(Revised on August 2024)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

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Volume – 15A
(Syllabi for Electrical and Electronics Engineering Programme Courses)

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ACADEMIC CURRICULA

Engineering Science Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21ASS101T	Course Name	APPLIED ENGINEERING MECHANICS	Course Category	S	ENGINEERING SCIENCES	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Aerospace Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*apply the concept of static equilibrium of particles and rigid bodies*
CLR-2:	*apply the concept of centroid and moment of inertia about different axes on static structures*
CLR-3:	*apply the concept of the dynamics of particles*
CLR-4:	*apply the concept of the dynamics of rigid bodies*
CLR-5:	*solve problems related to space mechanics*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*determine the forces under static equilibrium*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-	-
CO-2:	*calculate the centroids and determine moment of inertia*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	-	-	-
CO-3:	*determine the forces acting on particle for kinetics and kinematics*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-	-
CO-4:	*determine the forces acting on rigid body for kinetics and kinematics*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-	-
CO-5:	*solve the problems of orbital mechanics and projectile motions*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	-	-	-

Unit-1 - Statics of Particles	***9 Hour***
Fundamentals of mechanics - Forces on particles - Resolution and Resultant of forces - Principle of Transmissibility - Forces in space - Moment of force - Varignon's theorem - Equivalent system of forces -Free body diagram - Types of supports and Equilibrium of rigid bodies in two dimensions – Statically determinate and indeterminate structures	
Unit-2 - Properties of Surfaces and Volumes	***9 Hour***
Determination of centroids by integration - centroids of lines, areas and volumes - Determination of moment of inertia by integration, Parallel and Perpendicular axis theorems - Polar moment of inertia - Mass moment of inertia.	
Unit-3 - Dynamics of Particles	***9 Hour***
Rectilinear motion: Uniform motion and uniformly accelerated motion - rectangular components of velocity. Curvilinear Motion-Normal and tangential components - Radial and transverse components. Cylindrical coordinates, Newton's second law – D' Alembert's principle - Principle of work and energy, principle of impulse and momentum	
Unit-4 - Dynamics of Rigid Bodies	***9 Hour***
Kinematics of rigid bodies: Fixed axis rotation - General plane Motion-Absolute and Relative velocity in plane motion - Instantaneous center of rotation in plane motion - Principle of work and energy, Principle of impulse and momentum for the plane motion of a rigid body	
Unit-5 - Applications in Space Mechanics	***9 Hour***
Angular momentum of a particle- Rate Of change of angular momentum - Newton's Law of Gravitation – Kepler's Law of motion - Conservation of angular momentum, conservation of energy, Space Mechanics – Central Force Motion, Trajectory of a particle under a central force: Application to space mechanics	

Learning Resources	1. *Ferdinand P. Beer, E. Russell Johnston Jr., David Mazurek, Philip J Cornwell, "Vector Mechanics for Engineers: Statics and Dynamics", McGraw - Hill, New Delhi, Tenth Edition, 2013.*	2. *Shames, I.H., and Krishna Mohana Rao, G., "Engineering Mechanics (Statics and Dynamics)", Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), 2006.* 3. *NPTEL Engineering Mechanics Lectures by IIT Guwahati 'https://nptel.ac.in/courses/112103109/'*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*50%*	-	*50%*	-	*50%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. R. Krishnamurthy, Group Director, Design Group, DRDL-DRDO, Hyderabad, rkmurthy@drdl.drdo.in*	1. *Dr. K. M. Parammasivam , Ph.D., Post-doc (Japan), Professor, Department of Aerospace Engineering Madras Institute of Technology Campus, Anna University, Chennai, Indiamparams@mitindia.edu*	1. *Mr.K.B.Ravichandrakumar,, SRMIST*
2. *Dr. A Sakthivel, Scientist 'G', Regional Director RCMA (Helicopters), CEMILAC, DRDO, Bengaluru*	2. *Dr.S. Nadaraja pillai, Professor, Department of Mechanical Engineering, Sastra university Thanjavur, nadarajapillai@mech.sastra.edu*	2. *Mr. K.Iynthezhuthon, SRMIST*

ACADEMIC CURRICULA

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21EEC201J	Course Name	ANALOG ELECTRONICS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*21EES101T*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*develop amplifier circuits in the field of electronics*
CLR-2:	*evolve oscillator circuits in audio and radio applications*
CLR-3:	*develop op-amp circuits for linear and nonlinear applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*design voltage, power and feedback amplifiers*	*3*	-	*3*	-	-	-	-	-	*2*	*2*	-	-	*3*	-	-
CO-2:	*design oscillators and multivibrators*	*3*	-	*3*	-	-	-	-	-	*2*	*2*	-	-	*3*	-	-
CO-3:	*design wave generating circuits, filters and converters employing op-amps*	*3*	-	*3*	-	*2*	-	-	-	*2*	*2*	-	-	*3*	*2*	-

Unit-1 - Small Signal Amplifiers ***15 Hour***

Biasing methods of BJT in CE configuration- Operation of CE, CB, CC Amplifier- h-parameters- small and large signal analysis of amplifiers- Bias stability - Biasing methods of JFET - Operation of JFET (CS) amplifier- Biasing methods of MOSFET (CS) - Small signal analysis of CS amplifier- Design of amplifier circuits.

Laboratory Practice: *Low voltage audio amplifiers.*

Unit-2 - Power Amplifiers and Feedback Amplifiers ***15 Hour***

Power amplifiers-Class A, B, C power amplifier-Frequency response and Efficiency of RC coupled and Transformer coupled class A power amplifier-Operation of Class B and Class AB push pull power amplifier-Class C power amplifiers- Design of power amplifiers. Operation and analysis of Differential amplifier-Cascode and Cascade circuits. Feedback amplifiers –Types and analysis of feedback amplifiers-Design of feedback amplifiers.

Laboratory Practice*: Power and feedback amplifiers.*

Unit-3 - Oscillators and Multivibrators ***15 Hour***

Oscillators-classification-Analysis of RC Phase shift oscillator and Hartley's oscillator - Armstrong oscillator-Crystal Oscillator-UJT Relaxation Oscillators-Design of Oscillators-Multivibrator-Types-Operation and analysis of Astable Multivibrator and Monostable Multivibrator-Design of multivibrators-Voltage-time and current-time based circuits-Series and shunt voltage regulator using transistors.

Laboratory Practice*: Oscillators and multivibrators.*

Unit-4 - Op - Amp Characteristics and Applications ***15 Hour***

Introduction to Linear ICs and Fabrication process-DC and AC characteristics of IC741 op amp-Linear and Non-Linear Applications of op-amp- Design on linear and non-linear applications of op-amp. IC 555 Timer in Astable and Monostable operation - Oscillators- Wein bridge Oscillator using IC 741. Voltage regulator using IC 723. Simple MOSFET based op-amp circuits.

Laboratory Practice*: Op-amp applications.*

Unit-5 - Filters and Converters ***15 Hour***

Filter basics and types, Design of I and II Order LPF and HPF, Design of BPF and BRF- Switched variable filters and state variable filters- Classification and operation of Analog to Digital converters and Digital to Analog converters.

Laboratory Practice*: Filters and converters.*

Learning Resources	1. *Stephen H. Lewis, Robert G. Meyer, Paul R. Gray, Paul J. Hurst, "Analysis & Design of Analog Integrated Circuits", Wiley & Sons, Incorporated, John, fifth edition, 2009.* 2. *Robert L. Boylestad, Louis Nashelsky, "Electronic Devices and Circuit Theory", Pearson Education India, eleventh edition, 2015.*	3. *Jacob Millman, Christos C. Halkias, Chetan D. Parikh, "Integrated Electronics: Analog and Digital Circuits and Systems", Tata Mcgraw Hill Education Private Limited, second edition, 2011.* 4. *R. A. Gayakwad, "Op-Amps and Linear Integrated Circuit", Prentice Hall of India, fourth edition, 2004.* 5. *S. Smith, "Microelectronics Circuits", Oxford, fifth edition, 2005.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Manikanda Natarajan, Seshasayee Paper and Boards Limited, Tirunelveli*	1. *Dr. A. Venkadesan, NIT, Puducherry*	1. *Dr. R. C. Ilambirai, SRMIST*
2. *Mr. Deepan, TANGEDCO*	2. *Dr. R. Ramesh, Anna University*	2. *Dr. N. Kalaiarasi, SRMIST*

Course Code	21EEC202T	Course Name	ELECTROMAGNETIC THEORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	1	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide the basic skills required to understand, develop, and solve various engineering problems in electrostatic field and its applications*
CLR-2:	*acquaint with the static magnetic field and time varying field for the applications in engineering field*
CLR-3:	*emphasize on the electromagnetic wave concepts for obtaining solution to real time problems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*formulate potential problems within electrostatics field and solve it in simple geometries using numerical, separation of variables and the method of images*	*3*	*3*	-	-	-	-	-	-	-	*2*	-	-	*1*	-	-
CO-2:	*analyze the concept of magneto static fields and time varying field for all engineering applications*	*3*	*3*	-	-	-	-	-	-	-	*2*	-	-	*1*	-	-
CO-3:	*technically analyze and solve the practical challenges in application of electromagnetic wave*	*3*	*3*	-	-	-	-	-	-	-	*2*	-	-	-	-	-

Unit-1 - Basics of Electrostatics ***9 Hour***

Sources and effects of electromagnetic fields, Coordinate Systems, Gradient, Divergence, Curl, Stokes and Divergence theorem, Coulombs Law and its application, Electric Field Intensity, Field due to discrete and continuous charges, Torque on an Electric Dipole in an Electric Field, Gauss's law and applications. Equipotential plots.

Unit-2 - Electrostatics ***9 Hour***

Potential theory, Electric field in free space, conductors, dielectrics, Dielectric polarization, Dielectric strength, Electric field in multiple dielectrics, Boundary conditions, Poisson's and Laplace's equations in electrostatic field, Capacitance calculation, Energy Stored and Energy Density in a Static Electric Field, Applications of electrostatics.

Unit-3 - Magnetostatics ***9 Hour***

Static Magnetic Fields, Lorentz force, magnetic field intensity (H), Biot–Savart's Law, Ampere's Circuit Law, Oerstead's experiment, H due to straight conductors, circular loop, infinite sheet of current, flux density (B) for coaxial cables, Magnetization, Magnetic field in multiple media, Boundary conditions for static magnetic field, Scalar and vector potential, inductance calculation for coaxial cable, Magneto-static applications.

Unit-4 - Time Varying Electromagnetic Field ***9 Hour***

Magnetic potential, Faraday's law of Electromagnetic induction, transformer EMF, Displacement current, conduction current, Maxwell's equation, Phasor representation of time harmonic field, Energy in quasi-stationary Fields Case study on real time applications of Maxwell's equations, Applications of Poynting theorem, Software tool for 3D electromagnetic field simulations.

Unit-5 - Electromagnetic Waves ***9 Hour***

Electromagnetic wave generation and Helmholtz's equations. Wave parameters- velocity, intrinsic impedance- propagation constants, Skin depth, Wave equation for lossy dielectric, lossless dielectrics and conductors, Standing wave, Plane wave reflection and refraction, incidence of plane wave at the boundary between two region, Fresnel's coefficient, Goos-Hanchen effect, Snells law, Reflection coefficient, Transmission coefficient, Brewster and critical angle.

Learning Resources	1. *Mathew N. O. Sadiku, "Principles of Electromagnetics", Oxford University Press Inc., sixth edition, 2015.* 2. *William H. Hayt and John A. Buck, "Engineering Electromagnetics", McGraw Hill Special Indian edition, eighth edition, 2017.* 3. *Kraus and Fleish, "Electromagnetics with Applications", McGraw Hill International Editions, fifth edition, 2010.*	4. *Joseph. A.Edminister, "Schaum's Outline of Electromagnetics", (Schaum's Outline Series), McGraw Hill, fourth edition, 2013.* 5. *S.P.Ghosh, Lipika Datta, "Electromagnetic Field Theory", McGraw Hill Education (India) Private Limited, first edition, 2012.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*15%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*15%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Bhaskarsahu, Schneider Electric Ltd.*	1. *Dr. K. S. Swarup, IIT Madras*	1. *Dr. R. Rajarajeswari, SRMIST*
2. *Mrs.S. Sweet Annie Grace, ISRO*	2. *Dr. A. Venkadesan, NIT, Karaikal*	2. *Dr. D. Anitha, SRMIST*

Course Code	21EEC203J	Course Name	ELECTRICAL MACHINES - I	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*21EES101T*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*apply the basic laws of electromagnetic induction in rotating machines*
CLR-2:	*understand the behavior of DC machines at no load and load conditions*
CLR-3:	*analyze the performance of transformer at various operating conditions*
CLR-4:	*predetermine the operating conditions of machines as per standard practices*
CLR-5:	*understand the design of DC machines and transformers*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*comprehend the basics of electromagnetics and concept of rotating machines*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*illustrate the characteristics of DC machines at various load conditions*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*identify the different types of transformers and analyze the performance using equivalent circuit*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*investigate the performance of DC machines and transformers by various tests*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*examine the main dimensions of DC machines and transformers*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Electro Magnetic Induction and Basic Concept in Rotating Machines — ***12 Hour***

Introduction to magnetic circuits – Magnetically induced EMF and force – AC operation of magnetic circuits – Hysteresis and Eddy current losses. Energy in magnetic systems – Field energy and mechanical force – Single and Multiple excited systems. MMF of distributed windings – Magnetic fields in rotating machines – Generated voltages – Torque.

Unit-2 - DC Machines — ***12 Hour***

Types of generators – Characteristics of DC generators – Commutation – Armature reaction - Parallel operation of DC generators – Applications. Types of motor – Characteristics of DC motors – Starters – Speed control – Losses and efficiency –Applications.

Laboratory Practice: *Characteristics of self and separately excited DC generators, Load test and speed control of shunt and series motors.*

Unit-3 - Transformers — ***12 Hour***

Parts of the single and three phase transformers – Condition for maximum efficiency - Transformer on No load and Load – Phasor diagram -- Equivalent circuit – Regulation, losses, efficiency - Three phase transformer connections - Parallel operation of single phase and three phase transformers - Auto transformer – Special transformers: High frequency, CT, PT, isolation, power, distribution, tap changing - on load, off load, phase shifting transformer.

Laboratory Practice: *Load test and parallel operation of single phase and three phase transformers.*

Unit-4 - Testing of DC Machines and Transformers — ***12 Hour***

Testing of DC machines: Brake test, Swinburne's test, Retardation test, Hopkinson's test - Testing of transformer: polarity test, load test, open circuit and short circuit test, Sumpner's test – All day efficiency.

Laboratory Practice: *Swinburne's test and Hopkinson's test on DC machines, Open circuit test, short circuit test and Sumpner's test on single phase transformer, Load test and parallel operation of single phase and three phase transformers.*

Unit-5 - Design of DC Machines and Transformers	***12 Hour***
Output Equation of DC machines - Choice of Specific Electric Loading and Specific Magnetic Loading, Separation of D and L, quantitative values. Output Equation of single and three phase transformers - Design of core and window dimensions of the transformer. ***Laboratory Practice:*** *CAD design of DC machines.*	

Learning Resources	1. *D. P. Kothari, I. J. Nagrath, "Electrical Machines", Tata-McGraw Hill, fifth edition, 2017.* 2. *A. E. Fitzgerald, C. Kingsley, "Electric Machinery", McGraw Hill Education, sixth edition, 2013.*	3. *Paul C. Krause, Oleg Wasynezuk, Scott D. Sudhoff, "Analysis of electric machinery and Drive systems", IEEE Series, John Wiley and Sons, third edition, 2013.* 4. *Sawhney, A.K., "A Course in Electrical Machine Design", Dhanpat Rai and Sons, fourth edition, 2017.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. V. Kaushik, Ather Energy*	1. *Dr. B. ChittiBabu, IIITDM Kanchipuram*	1. *Dr. V. Pradeep, SRMIST*
2. *Mr. Muralikrishna, National Instruments*	2. *Dr. V. Jamuna, Jerusalem College of Engineering*	2. *Dr. K. Vijayakumar, SRMIST*

Course Code	21EEC204J	Course Name	DIGITAL SYSTEM DESIGN	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*familiarize the concepts of digital logic circuits for real time applications*
CLR-2:	*introduce simulation and analysis of digital circuits using VHDL platform*
CLR-3:	*develop simple programming skills using microprocessors*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*design real time digital circuits for the given specifications*	*3*	-	*3*	-	-	-	-	-	-	*2*	-	-	*3*	-	-
CO-2:	*acquire knowledge on VHDL synthesis and simulation of digital circuits*	*3*	-	-	-	*2*	-	-	-	-	*2*	-	-	-	-	-
CO-3:	*write basic data manipulation programs using 8085 microprocessors*	*3*	-	-	-	-	-	-	-	-	*2*	-	-	-	-	-

Unit-1 - Combinational Logic I **15 Hour**

Boolean Algebra, Combinational function minimization using Boolean Algebra, Canonical forms, Kmap and Quine McCluskey method of simplification – 4,5 variables, Implementation of combinational circuits - adder, subtractor, multiplier, comparator, parity checker/generator, ripple adder/subtractor, carry look ahead adder, BCD adder, Code converters.

Laboratory Practice: *Realization of simple digital system to satisfy a given condition, Design of code converters.*

Unit-2 -Combinational Logic II **15 Hour**

Implementation of combinational circuits - Multiplexer, Demultiplexer, Encoder, Decoder, PLA, PROM, Barrel Shifter using multiplexer, ALU design, Digital logic families – characteristics, DTL, TTL, CMOS technology.

Laboratory Practice: *Realization of Boolean expression using MUX, Design of BCD to 7 segment decoders, Realization of BCD adder.*

Unit-3 - Sequential Circuits I **15 Hour**

Introduction to latches/Flip flop, Realization of one flip flop using another flip flop, Shift registers – Types, Universal shift registers, Counter Design, Mod counting, Random counting, Ring counter, Johnson counter, Finite state machines: Moore's model & Mealy's model, Analysis of synchronous sequential circuits.

Laboratory Practice: *Design of counters, Design and implementation of shift registers, Design and implementation of synchronous sequential circuits.*

Unit-4 - Sequential Circuits II **15 Hour**

Introduction to asynchronous sequential circuit, Design of asynchronous sequential circuit, Cycles and Races, Analysis of asynchronous sequential circuits, Asynchronous counter, VHDL programming basics, Types of VHDL modelling, Logic circuit synthesis with Xilinx ISE WebPACK Design, Simple VHDL coding for combinational and sequential circuits.

Laboratory Practice: *Design of asynchronous Counters, VHDL coding of combinational circuit, VHDL coding of sequential circuit.*

Unit-5 - Introduction to Processors **15 Hour**

Evolution of Microprocessors, Microcontrollers and Computers, 8085 Microprocessor pin diagram, 8085 Microprocessor architecture, Machine cycle – Opcode fetch, memory read and write, I/O read and write, Address decoding, Instruction set – Arithmetic & Logical instructions, Load/ store instructions, Addressing modes, Simple programs.

Laboratory Practice: *Programming 8085 to perform arithmetic operation on 8-bit numbers, Programming 8085 to sort numbers in an array, Programming 8085 to display Fibonacci Series.*

Learning Resources	1. *Ciletti, Michael D., and Mano, M. Morris, "Digital Design: With an Introduction to Verilog HDL, VHDL, and System Verilog", Pearson, sixth edition, 2012.* 2. *John F. Wakerly, "Digital Design: Principles and Practices", third edition, 2000.*	3. *Mohammad Karim, Xinghao Chen, "Digital Design-Basic Concepts and Principles", CRC press, Taylor and Francis Group, first edition, 2007.* 4. *Ramesh Gaonkar, "Microprocessor Architecture, Programming and Applications with the 8085", Penram International Publishing Pvt. Ltd, sixth edition, 2013.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*10%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*10%*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*20%*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*20%*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*20%*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*20%*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Bhaskarsahu, Schneider Electric Ltd.*	1. *Dr. K. S. Swarup, IIT Madras*	1. *Dr. D. Anitha, SRMIST*
2. *Mr. Manikandan P V, Intel Technology India Pvt Ltd*	2. *Dr. R. Subha, M S Ramaiah Institute of Technology*	2. *Dr. R. Palanisamy, SRMIST*

Course Code	21EEC205J	Course Name	ELECTRICAL MACHINES - II	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*21EES101T*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the operation of single and three phase induction motors*
CLR-2:	*understand the behavior of synchronous generator at no load and load condition*
CLR-3:	*examine the working and characteristics of synchronous motor*
CLR-4:	*illustrate the design of AC machines*
CLR-5:	*learn the operation of BLDC motor and PMSM*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*interpret the performance of single and three phase induction motors*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*examine the performance of synchronous generator in terms of voltage regulation, parallel operation and synchronizing capability*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*analyze the performance of synchronous motor using various testing methods*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*estimate the dimensions of AC machines*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*illustrate the operations and characteristics of BLDC motor and PMSM*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Induction Machines	***12 Hour***
Three phase induction motors: Torque slip characteristics - Equivalent circuit – Tests – Losses – Performance evaluation – Generating mode, Electric Braking mode – Cogging and Crawling -Starting– Speed control – Slip power recovery scheme. Single phase induction motors: Double field revolving theory – Torque slip characteristics – Equivalent circuit – Tests - Performance analysis – Starting methods.	
Laboratory Practice: *No load, blocked rotor tests for determining equivalent circuit and circle diagram and load test of induction motors, Induction generator, Electric Braking.*	
Unit-2 - Synchronous Generator	***12 Hour***
EMF equation - armature reaction – Synchronous reactance – Determination of voltage regulation – Synchronizing to infinite bus bars – Parallel operation of synchronous generators – Salient pole synchronous machine.	
Laboratory Practice: *Load test on 3 phase alternator, Voltage regulation using EMF, MMF and Potier reactance method.*	
Unit-3 - Synchronous Motor	***12 Hour***
Torque and power relations – Starting methods – V curves and inverted V curves – Hunting and suppression methods – Short circuit transient and capability curve –Synchronous condenser.	
Laboratory Practice: *Determination of X_d and X_q of salient pole machine, Determination of 'V' and inverted 'V' curves in synchronous motor.*	
Unit-4 - Design of AC Machines	***12 Hour***
Output equation of three phase induction and synchronous machine - Main dimensions of induction motor - Choice of Specific Electric and Magnetic Loading - Separation of D and L.	
Laboratory Practice: *CAD design of AC machines.*	

Unit-5 - BLDC and PMSM		***12 Hour***
BLDC Motor –Classification - Equivalent Circuit and Torque Equation - Performance Characteristics of BLDC motor – Applications. PMSM Motor –EMF and Torque Equation - Performance Characteristics of PMSM motor – Applications. ***Laboratory Practice:*** *Performance evaluation of BLDC motor and PMSM.*		
Learning Resources	1. *M.G.Say, "The Performance and Design of Alternating Current machines", Tata-McGraw Hill, first edition, 2004.* 2. *T.J.E. Miller, "Permanent Magnet and Reluctance Motor Drives", Clarendon Press, Oxford, second edition, 1988.*	3. *J. B. Gupta, "Theory & Performance of Electrical Machines", S.K.Kataria and Sons, fifteenth edition, 2015.* 4. *Sawhney, A.K., "A Course in Electrical Machine Design", Dhanpat Rai and Sons, 1984.* 5. *.https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-685-electric-machines-fall-2013/index.htm*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. V. Kaushik, Ather Energy*	1. *Dr. V. Jamuna, Jerusalem College of Engineering*	1. *Dr. V. Pradeep, SRMIST*
2. *Mr. Muralikrishna, National Instruments*	2. *Dr. B. ChittiBabu, IIITDM Kanchipuram*	2. *Dr. K. Vijayakumar, SRMIST*

Course Code	21EEC206J	Course Name	CONTROL SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*interpret a physical system in s domain representation*
CLR-2:	*determine the time response of linear systems to input signals*
CLR-3:	*understand the need of compensator design in time and frequency domain*
CLR-4:	*comprehend the state space model to test the controllability and observability of a system*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply mathematical modeling on physical systems*	*3*	-	*1*	*2*	*2*	-	-	-	-	-	-	-	-	-	-
CO-2:	*analyze the transient and steady state response of physical systems*	*3*	-	*3*	*3*	*3*	-	-	-	-	-	-	-	*2*	*2*	-
CO-3:	*design the compensators for time and frequency domain specifications of physical systems*	*3*	-	*3*	*3*	*3*	-	-	-	-	-	-	-	*2*	*2*	-
CO-4:	*apply the concept of state space analysis*	*3*	-	*3*	*2*	*3*	-	-	-	-	-	-	-	-	-	-

Unit-1 - Mathematical Modeling of Physical Systems ***12 Hour***

Basic Control System Components, Classification of control systems. Terminology of automatic control systems, Principles and effects of feed forward control systems. Principles and effects of feedback control systems, Mathematical modelling of electrical and mechanical systems, Block diagram reduction direct method, Signal flow graph, Linearization.

Laboratory Practice: *Linearization of amplifier circuit using BJT, Modelling of reactor applied to biological process industry and Performance analysis of a motor driving a load through a gear train*

Unit-2 - Transient and Steady State Response Analysis ***12 Hour***

Standard test signals ; Response of first order systems to standard test signals, Step response of second order systems, Different damping conditions, Time domain specifications, Steady state error, Static and dynamic error coefficients, Poles and zeros of a transfer function, Graphical evaluation, BIBO Stability and its important, Location of poles and stability, Routh Hurwitz criterion, Stability condition and its limitation, Effects of proportional, integral and derivative control actions on system performance, PID controller tuning using Ziegler – Nichols tuning rules.

Laboratory Practice: *Time response analysis of different standard test signals in software platform (BJT), Practice on effect of feedback on disturbance in the design of PID controller to adjust the duty cycle in voltage mode-controlled boost converter and Tuning of PID controller based on the required time domain specifications.*

Unit-3 - Compensator Design in Time Domain ***12 Hour***

Properties of the Root Loci, Construction of root loci, Gain limitation for stability condition, Effects of adding poles on the root loci, Effects of adding zeros on the root loci, Need for compensators, Classifications of compensators, transfer function of compensators, pole zero plot of compensators, Design of lead, lag and lead-lag compensator.

Laboratory Practice: *Plotting root locus of a transfer function using a simulator tank level estimation control, Modelling and control analysis of simple electric network and stability analysis of second order system using time and frequency domain approach.*

Unit-4 - Compensator Design in Frequency Domain	***12 Hour***
Introduction to frequency domain analysis, Frequency response plots of dynamic systems, Frequency response measurements, Performance specifications in the frequency domain, Log magnitude and phase diagrams, Determination of Frequency domain specifications. Phase margin and Gain margin, Stability Analysis using Bode Plots, Procedure for plotting bode plot, Stability margin on the bode plot, Polar plot, Nyquist stability criterion, Stability analysis using nyquist plot, Design of lead, lag and lead-lag compensator. ***Laboratory Practice:*** *Analysis of frequency response characteristics of second order system, design, determination of transfer function and frequency response for lag, lead network and Stability analysis of a system adding a pole / zero and lag lead compensator*	
Unit-5 - Concept of State Space Model	***12 Hour***
Concepts of state, state variables, state model, State differential equation using physical variables, State diagram representation, State space analysis by using phase variable form, Formation of state space equation, Relationship between state equation and transfer functions, Conversion of state space to transfer function, Solution of state equation; State Transition Matrix and it's Properties, Importance of controllability and observability, Formation of controllability and observability matrix. ***Laboratory Practice:*** *State space model for classical transfer function and design and tuning a PID controller, analysis of twin rotor multi input multi output system and Modelling and control of DC motor drive in state space approach.*	

Learning Resources	1. *J Nagarath and M.Gopal, "Control systems engineering", new age international publication, seventh edition, 2021.* 2. *Farid Golnaraghi, Benjamin C. Kuo, "Automatic Control Systems", McGraw-Hill Professional, tenth edition, 2017.* 3. *Katsuhiko Ogata, "Modern control engineering", Pearson publication, fifth edition, 2017.* 4. *Gene F. Franklin, J. David Powell and Abbas Emami-Naeini, "Feedback Control of Dynamic Systems", Pearson Education India Publications, sixth edition, 2008.*	5. *Graham C. Goodwin, Stefan F. Graebe, Mario E. Salgado, "Control system design", Pearson Education, second edition, 2001.* 6. *Norman S. Nice, "Control Systems Engineering", seventh edition, 2014.* 7. *Richard C. Dorf and Robert H. Bishop. "Modern Control Systems", Pearson Prentice Hall Publications, twelfth edition, 2010.* 8. *Online course material: Platform- NPTEL, Author – Prof. Ramkrishna Pasumarthy, IIT Madras, Web link: https://nptel.ac.in/courses/108106098*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*10%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*10%*	*20%*	*-*
Level 3	*Apply*	*20%*	*-*	*-*	*20%*	*30%*	*-*
Level 4	*Analyze*	*20%*	*-*	*-*	*20%*	*30%*	*-*
Level 5	*Evaluate*	*10%*	*-*	*-*	*20%*	*-*	*-*
Level 6	*Create*	*10%*	*-*	*-*	*20%*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. M. Sendhil, BHEL, Trichy*	1. *Dr. A. Venkatesan, NIT Puducherry*	1. *Dr. T. M. Thamizh Thentral, SRMIST*
2. *Mr. R. Kalidoss, TANGEDCO, Tiruchirappalli*	2. *Dr. V. Sankaranarayanan, NIT Trichy*	2. *Dr. A. Suresh Kumar, SRMIST*

Course Code	21EEC207J	Course Name	SENSORS AND INSTRUMENTS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*familiarize with the concepts and terminologies of various sensors*
CLR-2:	*gain knowledge on magnetic sensor*
CLR-3:	*understand the features of measuring instruments and bridge circuits*
CLR-4:	*learn about analog meters for power and energy measurements*
CLR-5:	*learn about digital instruments and miscellaneous sensors*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the working of various sensor and measuring instruments*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*	*1*	-
CO-2:	*measure the unknown parameters using bridges and instruments*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*	*1*	-
CO-3:	*identify the suitable sensor and apply for real time applications*	*2*	-	-	-	-	-	-	-	-	-	-	-	*1*	*1*	-
CO-4:	*apply the different analog meters for power and energy measurements*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*	*1*	-
CO-5:	*understand the concept of digital instruments and miscellaneous sensors*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*	*1*	-

Unit-1 - Electromechanical and Temperature Sensor — ***12 Hour***

Definition, principle of sensing and transduction, classification. Potentiometer, Strain gauge, Temperature Sensor, Temperature measurement using optical fibers, Piezoelectric sensor.
Laboratory Practice: *Loading effect of potentiometer, Design and analysis of Strain gauge based application. (Weight and Beam deflection measurement), Design of temperature measurement system for electrical application (Batteries and Motors).*

Unit-2 - Magnetic Sensor — ***12 Hour***

Inductive sensor: RVDT, Synchro's, Hall effect transducer: Measurement of Current, Yoke coil sensor, Eddy current sensor, Measurement of leakage flux using flux meter.
Laboratory Practice: *Characteristics of Piezo-electric Transducer, Characteristics of Synchros, Design a hall effect sensor based speed control system for vehicle.*

Unit-3 - DC and AC Bridges — ***12 Hour***

Wheatstone Bridge, Kelvin's Bridge, Kelvin's Double Bridge, Maxwell's Inductance Bridge, Schering's Bridge, Measurement of high voltage Schering Bridge
Laboratory Practice: *Measurement of Resistance using bridge circuit, Measurement of L and C using bridge circuit, Design a Wheatstone bridge along with operational amplifier is used to measure the physical parameters like temperature.*

Unit-4 - Analog Meters and Measurements — ***12 Hour***

Principle and types of voltmeters, ammeters, Current Transformer and Potential Transformer, Power factor Meter: Electro dynamo, Moving Iron meter, Electrical Resonance Frequency Meter, Phase sequence indicator, Measurement of RMS Value of High voltage, Measurement of VAh meter using bridge connected rectifier, Measurement of reactive power using wattmeter in single phase circuit.
Laboratory Practice: *Real time Measurement of power, Real time Measurement of energy, Measurement of harmonics using Power quality analyzer.*

Unit-5 - Digital Meters and Miscellaneous Sensors	***12 Hour***
Digital Voltmeter: Ramp Type, Digital Multimeter: Operation, Block Diagram, Digital energy meter for measuring power, Digital Storage oscilloscope, Harmonics Analyzer, Accelerometer and Vibration Sensor, Proximity sensor, Ultrasonic and Laser Sensor. ***Laboratory Practice:*** *Design an obstacle detection using proximity sensor, IR motion sensor: Design a motion sensitive intruder alarming system, Ultrasonic proximity sensor: Measure the distance of an object using SONAR principle by ultrasonic proximity sensor, Calibration of Thermocouples.*	

Learning Resources	1. *Sawhney. A.K, "A Course in Electrical and Electronics Measurements", Dhanpat Rai and Company Private Limited, nineteenth revised edition, 2011.* 2. *D. Patranabis, "Sensor & transducers", PHI Learning Private Limited, second edition, 2003.*	3. *Doebelin. E.A, "Measurement Systems – Applications and Design", Tata McGraw Hill, New York, seventh edition, 2019.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Himanshu Shekhar, Energy Products & Systems Engineering (EPSE), L&T Energy*	1. *Dr. E. Paul Brinard, IIIT, Chittoor*	1. *Dr. A. Dominic Savio, SRMIST*
2. *Mrs. Kala Smile Ross, Dow Chemicals, Chennai*	2. *Dr. Vanaja Ranjan, CEG Anna University*	2. *Dr. R. Narayanamoorthi, SRMIST*

Course Code	21EEC301J	Course Name	POWER ELECTRONICS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	21EEC101J, 21EEC201J	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	describe the characteristics of various power semiconductor switches and design their driver and protection circuits
CLR-2:	comprehend the operation and effect of various loads on rectifiers, inverters and AC-AC converters functioning
CLR-3:	formulate, design and analyze DC-DC isolated and non –isolated converters
CLR-4:	compare different types of pulse width modulation schemes and analyze power converters performance
CLR-5:	identify the role of power electronics in emerging areas of engineering applications

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	apply the knowledge of semiconductor physics and identify an appropriate power semiconductor device along with drive and protection circuits for a given converter circuit	3	2	2	-	-	-	-	-	2	-	-	-	2	-	-
CO-2:	design power converter circuits for engineering applications	3	3	3	-	2	-	-	-	2	-	-	-	3	-	-
CO-3:	analyze converter circuits based on power conversion for different applications	3	3	2	-	2	-	-	-	2	-	-	-	2	-	-

Unit-1 - Power Semiconductor Devices — **15 Hour**

Introduction-Review of power semiconductor switches: Power diodes, Thyristors: SCR, GTO- Power transistors: BJT, MOSFET, IGBT-Static and dynamic characteristics- New Semiconductor materials for power devices- Wide-band gap semiconductors - Selection of switches - Design of snubber circuits, protection-isolation, Thermal modeling and design of heat sink.

Laboratory Practice: *Design of gate driver circuits.*

Unit-2 - Controlled Rectifiers — **15 Hour**

Design and analysis of single-phase half wave diode rectifier - Three phase full bridge diode rectifier- Phase controlled rectifiers: Design of single phase half-controlled rectifiers and Three phase half-controlled rectifiers- Effect of source inductance on controlled rectifiers - Twelve-pulse Rectifiers-Dual converters.

Laboratory Practice: *Design and analysis of single phase and three phase fully controlled rectifiers.*

Unit-3 - Choppers — **15 Hour**

Chopper operation and Control Strategies-Design and analysis of non-isolated converters with continuous, and discontinuous modes- non-ideal switches and converter performance –Design of isolated topologies-Converter selection, Multiport converters derivation - Concept of resonant switching - EMI filtering-Input filter design.

Laboratory Practice: *Design of non-isolated converters.*

Unit-4 - Inverters — **15 Hour**

Voltage source inverters- Design of single-phase full bridge inverter- Three phase full bridge inverter - Power computations using Fourier series - Harmonic distortion analysis- Harmonic guidelines-Development of pulse-width modulation schemes - Significance of dead time- Current controlled inverter.

Laboratory Practice: *Design and analysis of single phase and Three phase inverters, Design and analysis of multilevel inverter.*

Unit-5 - AC-AC Controllers	***15 Hour***
Types of AC-AC voltage regulation-Design of single phase AC voltage controller- Analysis of three phase AC voltage controller - Single phase to single phase cyclo-converters-Matrix converter. Various power electronic applications: Power conditioners, UPS, HVDC, induction heating, speed control of induction motor, EV and renewable energy integration.	
Laboratory Practice: *AC-AC voltage regulation- Power electronic interfaces for renewable energy and EV applications.*	

Learning Resources		
	1. *Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics - Converters, Applications and Design", Wiley India, third edition, 2022.* 2. *Rashid M H, "Power Electronics: Circuits, Devices and Applications", Pearson Education, India, fourth edition, 2017.* 3. *P.S.Bimbhra P.S., "Power Electronics", Khanna Publishers, sixth edition, 2018.*	4. *L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, 2015.* 5. *Robert W. Erickson, Dragon Maksimovic, "Fundamentals of Power Electronics", Springer, third edition, 2020.* 6. *Daniel W.Hart, "Power Electronics", McGraw Hill Higher Education, 2017.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*5%*	*-*	*-*	*25%*	*20%*	*-*
Level 2	*Understand*	*5%*	*-*	*-*	*25%*	*20%*	*-*
Level 3	*Apply*	*15%*	*-*	*-*	*25%*	*30%*	*-*
Level 4	*Analyze*	*15%*	*-*	*-*	*25%*	*30%*	*-*
Level 5	*Evaluate*	*30%*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*30%*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Sitangshu Sekhar Biswas, Department of Atomic Energy, Kalpakkam*	1. *Dr. A. Kirubakaran, NIT, Warangal*	1. *Dr. N. Chellammal, SRMIST*
2. *Dr. M. Vishnu Prasad, Unistring Tech Solutions*	2. *Dr. S. Senthilkumar, NIT, Trichy*	2. *Dr. R. Sridhar, SRMIST*

Course Code	21EEC302T	Course Name	DIGITAL SIGNAL PROCESSING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	1	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*categorize the different types of signals and systems by their properties*
CLR-2:	*extract frequency domain signal using various Fourier transform*
CLR-3:	*acquire knowledge on the necessity of segregation on signals*
CLR-4:	*illustrate the spectrum of sampling, interpolation, and decimation*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify the continuous and discrete-time signals and systems*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*apply the concept of DFT for transforming time domain signal to frequency domain signal*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*design the digital IIR and FIR filters*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*analyze the concept of multirate signal processing*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Signals and Systems ***9 Hour***

Overview of signals and systems, Standard Discrete time signals- Classifications of Discrete time signals, Sampling and Sampling Theorem, Quantization and Coding- Aliasing, Effects of Aliasing -system properties (linearity, time-invariance, memory, causality, BIBO stability) - LTI systems described by linear constant coefficient difference equations (LCCDE) - impulse response and convolution- Simulation on continuous time signals, Simulation on discrete time signals, systems.

Unit-2 - Discrete Fourier Transform ***9 Hour***

System representation through differential equations, System representation through difference equations-Realization of discrete time systems: Direct form – I, Direct form – II, Cascade form, Parallel form- Discrete Fourier Transform (DFT), Calculation of DFT-DFT properties: Linearity, Periodicity, Circular convolution, DFT properties: Time reversal, Circular time shift, Parseval's theorem- DFT using DIT-FFT algorithm - Calculation of DFT using DIT-FFT, DFT using DIF-FFT algorithm, Calculation of DFT using DIF-FFT algorithm, Inverse DFT, Calculation of IDFT.

Unit-3 - IIR Filters ***9 Hour***

Design procedure of Analog Butterworth, Chebyshev Filter- Frequency transformation technique, Need of Pre-warping, Pre- warping- Quantitative treatment of Bilinear transform technique, Impulse invariance technique - Design of IIR Butterworth digital filters using bilinear transform technique and impulse invariant method-. Design of IIR Chebyshev digital filters using bilinear transform technique and Impulse invariant technique-Realization of IIR filters – Simulation on digital IIR Butterworth and Chebyshev filters.

Unit-4 - FIR Filters ***9 Hour***

Design procedure of FIR filter by window technique, Rectangular, Hamming, Hanning and Blackmann Windows, Kaiser window. Design of low pass FIR filter: Calculation of window coefficients, Design of high pass FIR filter: Calculation of filter coefficients, Design of band pass FIR filter: Calculation of window coefficients -Design of bandpass FIR filter: Calculation of filter coefficients, Design of band stop FIR filter: Determination of window coefficients, Design of band stop FIR filter: Determination of filter coefficients, Realization of FIR filters: Transversal realization structure, Linear phase realization structure, Polyphase realization structure, Cascade structure- Simulation on digital FIR low and high pass filters, Simulation on digital FIR band pass and band stop filters.

Unit-5 - Introduction to Multirate DSP ***9 Hour***

Introduction -Spectrum of down sampled signal and up-sampled signal- Anti-imaging filter- Identities- Cascading sample rate converter, Transversal structure and Poly phase structure of Decimator, Interpolator., multistage implementation of sampling rate conversion, Implementation of narrow band low pass filter, Filter Banks.

Learning Resources	1. *H. P. Hsu, "Signals and systems", Schaum's series, McGraw Hill Education, second edition, 2017.* 2. *S. Haykin and B. V. Veen, "Signals and Systems", John Wiley and Sons, second edition, 2021.* 3. *A. V. Oppenheim and R. W. Schafer, "Discrete-Time Signal Processing", Prentice Hall, third edition, 2014.*	4. *M. J. Robert, "Fundamentals of Signals and Systems", McGraw Hill Education, second edition, 2017.* 5. *J. G. Proakis and D. G. Manolakis, "Digital Signal Processing: Principles, Algorithms, and Applications", Pearson, fourth edition, 2014.* 6. *https://extension.ucsd.edu/courses-and-programs/signals-and-systems*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. P V Manikandan, Intel Technology India Pvt Ltd.*	1. *Dr. K. S. Swarup, IIT Madras*	1. *Dr. N. Kalaiarasi, SRMIST*
2. *Ms. Saranya, Samsung Technology Ltd*	2. *Dr. R. Subha, M S Ramaiah Institute of Technology*	2. *Dr. K. Mohanraj, SRMIST*

Course Code	21EEC303T	Course Name	POWER SYSTEM - I	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	1	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe and calculate different types of line parameters*
CLR-2:	*understand the electrical performance and mechanical design of transmission lines*
CLR-3:	*explain different types of power flow methods for calculating real and reactive power flow*
CLR-4:	*calculate fault current for a symmetrical and unsymmetrical fault in a power system*
CLR-5:	*discuss the steady state and transient stability studies*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify the different line parameters*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*calculate the efficiency and the mechanical strength of the overhead transmission line*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*examine real and reactive power flow in an electrical network*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*estimate the fault current for different types of faults in power system*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*calculate critical clearing angle and time under steady state and transient conditions*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Transmission Line Parameters and Tariff	***9 Hour***
Calculation of line parameters-Resistance, Inductance of transmission lines, Inductance of a single phase two wire line-three phase lines with symmetrical and unsymmetrical spacing-Capacitance of a single phase two wire line- three-phase line with symmetrical and unsymmetrical spacing. Representation of lines-Short –Medium-long lines, Equivalent Circuits. Objectives of tariffs – types of tariffs.	
Unit-2 - Modelling of Transmission Lines	***9 Hour***
Calculation of Voltage regulation and efficiency, Surge Impedance loading. Insulators in overhead line- underground cables-Sag in overhead line. Need for system studies in planning and operation of power system-Per phase analysis of symmetrical three-phase system- - Modeling of a generator, load, shunt capacitor, transmission line, -shunt reactor for power flow and short circuit studies.	
Unit-3 - Power Flow Analysis	***9 Hour***
Per unit representation- per unit reactance and impedance diagram, change of base -Formation of Y bus matrix-Power Flow Problem- -Bus Classification- Power Flow Equation, Gauss-Seidel method, Newton-Raphson method and Fast Decoupled Load Flow method.	
Unit-4 - Short Circuit Analysis	***9 Hour***
Formation of Z bus matrix-approximations in Short Circuit Analysis, Symmetrical Short Circuit Analysis-Symmetrical Component Transformation- Z bus in phase frame and sequence frame-Unsymmetrical Fault Analysis.	
Unit-5 - Stability Analysis	***9 Hour***
Power system stability: Steady state and transient stability concepts, synchronous machine modelling for stability studies swing equation, equal area criterion- solution of swing curve, multi machine stability, factors affecting stability.	

Learning Resources	1. *D.P. Kothari, I.J. Nagrath, "Power System Engineering", Mc Graw-Hill Publishing Company limited, second edition, 2008.* 2. *C. L. Wadwa, "Electric Power Systems", New Age International Publishers, 2016.* 3. *Hadi Saadat, "Power System Analysis", Tata McGraw Hill, seventh edition, 2015.*	4. *P. Kundur, "Power system stability and control", McGraw-Hill Education, second edition, 2022.* 5. *Pai M A, "Computer Techniques in Power System Analysis", Tata Mc Graw-Hill Publishing Company Ltd., second edition, 2007.* 6. *R. Jegadeesan, K.Vijayakumar, "Modern Power System Analysis with MATLAB", Pearson Education; first edition, 2020.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Bhaskarsahu, Schneider Electric Ltd.*	1. *Dr. K. S. Swarup, IIT Madras*	1. *Dr. P. Suresh, SRMIST*
2. *Dr. D. Maharajan, Hitachi Energy, Chennai*	2. *Dr. P. Somasundaram, Anna University*	2. *Mr. D. Ravichandran, SRMIST*

Course Code	21EEC304J	Course Name	POWER SYSTEM - II	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*acquire the knowledge on protection schemes and protection devices*
CLR-2:	*understand the control methods of frequency in power system*
CLR-3:	*understand the control methods of voltage in power system*
CLR-4:	*formulate the economic operation of power system*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*acquaint different protection schemes and the functionalities of relays, fuses and circuit breakers*	*3*	*3*	-	-	*3*	-	*2*	*2*	-	-	-	-	*3*	-	-
CO-2:	*analyze frequency control in single area and two area system*	*3*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-3:	*model excitation systems and analyze methods of voltage control*	*3*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-4:	*examine numerical methods of economic dispatch and unit commitment*	*3*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Power System Protection ***15 Hour***

Types of faults – Assumptions - Development of algorithm for SC studies - PC based integrated software for SC studies - Transformation to component quantities - SC studies of multiphase systems- Need of protection schemes - Zones of protection - Primary and backup protection - IEEE standards for protection-Wire pilot relaying: introduction: summation devices and sequence networks- problems in pilot relaying- pilot wire protection characteristic- pilot supervision- characteristic of pilot circuits- practical design considerations- typical protection schemes. Differential protection of bus, transformer and generator - Carrier pilot relaying: mode of communication- coupling equipment- signaling equipment- mode of signal transmission- carrier aided distance protection- Carrier phase comparison protection.

Laboratory Practice: *Power Flow and Fault analysis using simulation software, Generator protection using numeric protective relays.*

Unit-2 - Relays and Circuit Breakers ***15 Hour***

Electromechanical relays and static relays - Numerical relays - Relay setting calculation and its operation - Overvoltage due to lightning - Protection of transmission lines against lightning strokes - Basic Impulse Insulation level and Insulation coordination - Principle of Lightning arrestors - Fuse characteristics - Types of fuses - Design of circuit breakers - Testing of circuit breaker - Arc voltage and restriction - Restriking voltage and recovery voltage - Oil and air blast circuit breakers - Vacuum circuit breakers - Sulphur hexafluoride (SF6) breaker - HVDC circuit breaker - Testing of circuit breaker.

Laboratory Practice: *Relay coordination in Radial feeder protection scheme using over current, over voltage and under voltage relay, Study the characteristics of electromechanical earth fault relay*

Unit-3 - Frequency Control ***15 Hour***

Basic concepts of operation and control of power system - Plant and system level control - Load characteristics - Interaction of AVR and ALFC loops- Modelling of speed governing mechanisms - Regulation of two alternators in parallel - Concept of Control area - Closing ALFC loop -Static and Dynamic response single area system uncontrolled - Proportional plus integral controller, Static and Dynamic response of single area system controlled case - Modeling of Two area frequency control - Block diagram representation of two area system - Static and Dynamic response of two area system

Laboratory Practice: *Dynamic Response of ALFC in Single Area System, Dynamic Response of ALFC in Two Area System.*

Unit-4 - Voltage Control	***15 Hour***
Need for voltage control, Requirement of reactive power, Static Excitation systems, Brushless AC Excitation systems, Schematic diagram of brushless excitation system, Modelling of AVR and Exciter - Modelling of synchronous generator - Static performance of AVR loop - Dynamic response of AVR loop. Stability compensation - Voltage drop/rise in transmission lines - Methods of voltage control- shunt capacitors, shunt reactors, Methods of voltage control- tap changing. ***Laboratory Practice:*** *Stability Analysis of AVR With Stabilizer*	
Unit-5 - Economic Dispatch and Unit Commitment	***15 Hour***
Input-output characteristics of thermal units and Heat rate Curve - Input-output characteristics of Cost Curve - Optimum generation allocation neglecting network losses and inequality constraints - Optimum generation allocation neglecting network losses and inequality constraints numerical approach - Loss Coefficients - Transmission line loss formula - Incremental cost of received power - Penalty factors - Base point and Participation factor method -numerical approach - Statement of Unit Commitment problem - Problem constraints - Priority List method - numerical approach - Algorithmic steps of Dynamic programming. ***Laboratory Practice:*** *Economic dispatch neglecting losses, Economic dispatch including losses, Base point and Participation factor method, Priority List method of Unit Commitment problem.*	

Learning Resources	1. *Paithankar Y. G., S. R. Bhide., "Fundamentals of power system protection", PHI Learning Pvt. Ltd., tenth reprint edition, 2010.* 2. *Badriram & Vishwakarma, "Power System Protection", Tata McGraw-Hill Education, tenth reprint edition, 2015.* 3. *Olle.I.Elgerd, "Electric Energy systems theory- An Introduction", Tata McGraw Hill Education Pvt. Ltd., Thirty fourth reprint edition, 2010.*	4. *Allen J.Wood and Bruce F. Woollenburg, Gerald B.Sheble, "Power generation, operation and control", John Wiley and sons, third edition, 2013.* 5. *I.J.Nagrath and D.P.Kothari, "Power system engineering", Tata Mc Graw Hill publishing Ltd, second edition, 2007.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Bhaskarsahu, Schneider Electric Ltd.*	1. *Dr. K. S. Swarup, IIT Madras*	1. *Dr. D. Sattianadan, SRMIST*
2. *Dr. D. Maharajan, Hitachi Energy, Chennai.*	2. *Dr. P. Somasundaram, Anna University*	2. *Dr. P. Suresh, SRMIST*

Course Code	21EEC305P	Course Name	MICROCONTROLLER	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							1	0	4	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*impart knowledge on 8051and AVR microcontrollers*
CLR-2:	*experiment with microcontrollers by interfacing sensors and actuators*
CLR-3:	*design and build an Arduino based system*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*elucidate the working of microcontrollers*	*3*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
CO-2:	*demonstrate the use of microcontrollers for simple applications*	*3*	*3*	*3*	*3*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
CO-3:	*design, develop and demonstrate the real time project using Arduino considering realistic constraints*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*2*	*3*	*3*	*1*

Unit-1 - Introduction to Microcontrollers ***15 Hour***

Evolution of Microprocessor and Microcontroller, Architecture of 8051, Assembly language: Instruction set - Data transfer, Arithmetic, Logical and Branch Instructions, Bit manipulation instructions, Timing subroutines, Serial Data transmission, overview of interfacing devices, Introduction to Embedded system, Learning Arduino Platform, Introduction to AVR microcontroller, Architecture of ATmega328P, review of basic concepts of programming: Arduino data types-variables and constants-operators-control statements-Arrays and Functions, Arduino I/O functions, Incorporating Arduino time delay functions, Basic sensors and actuators using Arduino, Controlling Electrical appliances with relays, Using keyboard library to interface with Arduino-Interfacing DC motors to Arduino, Interfacing IoT with Arduino

Laboratory Practice and Project Design ***60 Hour***

Laboratory Practice:

Experiments using 8051: Transfer data serially between two kits, Interfacing ADC and DAC, seven segment display, Speed control of stepper motor.

Experiments using Arduino: Home Lighting control, Temperature measurement, DC Motor speed control, Solar Panel Tracking.

Project Design:

The students should work as a team of not more than 3 to develop an Arduino real time Project which involve:

- *Designing, developing, coding, demonstrating and implementing Arduino projects.*
- *Demonstrating competence in applying engineering design considering multiple realistic constraints (e.g., economic, environmental, sustainability, manufacturability, ethical, health and safety, social and political issues)*
- *Exhibiting mastery in technical writing, presentation skills and in preparing a formatted report on the project.*
- *Managing and working as a team in completing the project within the given time frame adhering to standards.*

Learning Resources	1. *Muhammad Ali Mazidi, Sarmad Naimi, Sepehr Naimi, "AVR Microcontroller and Embedded Systems: Using Assembly and C", Pearson Education India; first edition, 2013.* 2. *K. J. Ayala, "8051 Microcontroller", Delmar Cengage Learning, third edition, 2007.* 3. *Subrata Ghoshal, "8051 Microcontroller Internals, Instructions, Programming and Interfacing", Pearson Education Asia, second edition, 2014.*	4. *Louis E. Frenzel, "Handbook of Serial Communications Interfaces: A Comprehensive Compendium of Serial Digital Input/Output (I/O) Standards", Newnes; first edition, 2015.* 5. *Adeel Javed, "Building Arduino Projects for the Internet of Things: Experiments with Real-World Applications", A press; first edition, 2016.* 6. *Simon Monk, "Programming Arduino: Getting started with sketches", McGraw Hill, 2016.* 7. *John Boxall, "Arduino Workshop: A Hands-on Introduction with 65 projects", No starch Press, second edition, 2021.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		Formative CLA-1 Average of unit test (20%)		*Project Based Learning CLA-2 (60%)*		*Report and Viva Voce (20%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	-	*5%*	-	*30%*	-	-
Level 2	*Understand*	*30%*	-	-	*5%*	-	*30%*	-	-
Level 3	*Apply*	*20%*	-	-	*15%*	-	*20%*	-	-
Level 4	*Analyze*	*20%*	-	-	*15%*	-	*20%*	-	-
Level 5	*Evaluate*	-	-	-	*30%*	-	-	-	-
Level 6	*Create*	-	-	-	*30%*	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*		-	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. S.S. Biswas, Dept. of Atomic Energy, Kalpakkam*	1. *Dr. K. S. Swarup, IITM*	1. *Dr. D. Suchitra, SRMIST*
2. *Mr. Manikandan P V, Intel Technology India Pvt Ltd*	2. *Dr. R. Subha, M S Ramaiah Institute of Technology*	2. *Dr. R. Narayanamoorthi, SRMIST*

ACADEMIC CURRICULA

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21EEE301T	Course Name	MODELLING AND CONTROL OF SUSTAINABLE ENERGY SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the basics and control algorithms of smart grid*
CLR-2:	*acquire knowledge on modelling and control of solar PV system*
CLR-3:	*acquire knowledge on modelling and control of wind system*
CLR-4:	*understand the model and control of battery systems*
CLR-5:	*enrich knowledge of fuel cell technology*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*elaborate the concept and model of solar PV, wind, battery and fuel cells*	*3*	-	-	-	-	-	*2*	-	-	-	-	-	-	-	*3*
CO-2:	*summarize the control algorithms of solar PV, wind, battery and fuel cells*	*3*	-	-	-	-	-	*2*	-	-	-	-	-	-	-	*3*
CO-3:	*familiarize the investigation analysis of solar PV, wind, battery and fuel cell integrated power system*	*3*	-	-	-	-	-	*2*	-	-	-	-	-	-	-	*3*

Unit-1 - Modelling and Control of Smart Grid System	***9 Hour***
Introduction to Smart grid, Overview of phasor measurement units, Wide area monitoring and control, modelling and simulation of microgrid, smart grid infrastructure, control scheme for real and reactive power control, VSC control modelling, Current reference computations, DC voltage regulator, Current loop control, phase lock loop, Voltage modulation	
Unit-2 - Modelling of Solar PV System	***9 Hour***
Introduction to PV systems, stand-alone PV systems, Grid connected PV systems, system pre sizing, PV array modelling, power electronics converters, structure of converters, empirical modelling of the converters, circuit modelling, multi-agent systems, multi-agent system in power systems, distributed power systems, inverter control and applications	
Unit-3 - Modelling and Control of Wind Energy System	***9 Hour***
Introduction to Wind power development, wind turbine generator technology, challenges with wind power integration, principles of doubly fed induction generator, PQ control of doubly fed induction generator, grid side converter, rotor side converter, direct torque control of DFIGs, features of direct torque control, LVRT of DFIG, dynamic model of wind turbine, operating characteristics and model of full-scale converter wind turbine generator, grid connected FSC-WTG stability control.	
Unit-4 - Modelling of Battery System	***9 Hour***
Introduction to lithium-ion battery technology, battery working mechanism, lithium-ion battery characteristics, battery aging behavior analysis, lithium-ion battery applications, battery electrical equivalent circuit modelling – modelling method overview, battery state estimation methods- traditional state estimation methods, battery state of charge estimation, overview of battery system active control strategies.	
Unit-5 - Fuel Cell System	***9 Hour***
Introduction to fuel cell, fuel cell propulsion system for automobiles, system interactions, fuel cell auxiliary components model- compressor model, lumped model of the manifold dynamics, thermodynamics of gas mixtures, air cooler model, humidifier model, fuel cell stack model – stack voltage model, cathode flow model, anode flow model, membrane hydration model, Analysis of fuel cell system model- humidifier and hydrogen flow controls, steady state analysis.	

Learning Resources	1. *Wang, L. ed., "Modeling and control of sustainable power systems: Towards smarter and greener electric grids", Springer Science & Business Media, first edition, 2011.* 2. *Rekioua, D. and Matagne, E., "Optimization of photovoltaic power systems: modelization, simulation and control", Springer Science & Business Media, first edition, 2012.* 3. *Wu, Qiuwei, and Yuanzhang Sun, "Modeling and modern control of wind power", John Wiley and Sons, first edition, 2018.*	4. *Pukrushpan, J.T., Stefanopoulou, A.G. and Peng, H., "Control of fuel cell power systems: principles, modeling, analysis and feedback design" Springer Science and Business Media, first edition, 2004.* 5. *Wang, S., Fernandez, C., Chunmei, Y., Yongcun, F., Wen, C., Stroe, D.I. and Chen, Z., "Battery System Modeling", Elsevier, first edition, 2021.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Sudharshan, Larsen & Toubro Ltd.*	1. *Dr. K. Shanti Swarup, IIT Madras.*	1. *Ms. C. Nithya, SRMIST*
2. *Dr. Roosefert Mohan, Nelcast Ltd.*	2. *Dr. Ravi Kumar Pandi, Amrita Vishwa Vidyapeetham, Kollam*	2. *Dr. U. Sowmmiya, SRMIST*

Course Code	21EEE302T	Course Name	POWER QUALITY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*categorize the limitations of electrical power quantities and their characteristics*
CLR-2:	*realizing the causes and effects of sag and harmonics in the system network*
CLR-3:	*quantifying the power quality parameters and mitigation of issues*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*distinguish power quality problems and description of voltage sag and harmonics*	*3*	-	-	-	-	-	-	*1*	-	-	-	-	-	-	*2*
CO-2:	*recognize the mitigation techniques for various power quality issues*	*3*	-	-	-	-	-	-	-	*1*	-	-	-	-	-	*2*
CO-3:	*familiarize the measuring instruments for power quality parameters*	*3*	-	-	-	-	-	-	*1*	*1*	-	-	-	-	-	-

Unit-1 - Power Quality Problems ***9 Hour***

Power quality – Definition as per IEEE and IEC standards - Power quality evaluation procedure- Transients – voltage variations – Overvoltage - Undervoltage and sustained interruption - Sag- Swell and Interruption- Voltage Imbalance- Voltage fluctuations - Waveform distortion – DC offset, Harmonics – Interharmonics - Notching, Noise - Power frequency variations - Computer Manufacturing standard curves.

Unit-2 - Voltage Sag ***9 Hour***

Voltage sags – Sources of voltage sags- Estimation of voltage sag performance – Equipment sensitive to voltage sags- sag performance evaluation- Causes of voltage Sags – causes of interruptions- Traditional reliability indices of the distribution system – SAIFI - SAIDI- CAIFI – CAIDI – ASAI.

Unit-3 - Harmonics ***9 Hour***

Harmonic distortion- Current distortion – Voltage Distortions - Harmonics versus transients- Non-sinusoidal conditions – True and Displacement power factor - Harmonic phase sequences- Harmonic indices – Total Harmonic Distortion (THD) - Total Demand Distortion (TDD)- Harmonic sources from commercial loads – Single phase power supplies – Harmonic sources from industrial loads – DC drives- Harmonic sources from industrial loads – AC drives- Harmonic sources from industrial loads - Arcing and Saturable devices.

Unit-4 - Issues and Mitigation of Power Quality Problems ***9 Hour***

Need of power quality enhancements - custom power devices- Active filter- Series active filter- Shunt active filter- Distribution Static Compensator - Passive filters: Series filters- shunt filters- Hybrid Passive filters- Unified Power Quality Conditioner(UPQC)- Control strategies – PQ theory- Synchronous detection method- Power quality issues in renewable energy integration - Power quality issues in microgrid – power quality issues and mitigation in HEVs – Ride through techniques for voltage sag and swell – Flicker compensation in arc loads.

Unit-5 - Power Quality Instruments ***9 Hour***

IEEE and IEC standards for measurements parameters – Measurement methodologies - Power quality monitoring – Need for power quality monitoring- measurement locations - Digital fault recorders, Smart relays- Voltage recorders – power monitors - revenue meters- selection of power quality measurement instrument- Disturbance analyzers- Spectrum analyzer- Flicker measurement techniques

Learning Resources	1. *Arindam Ghosh, "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, third edition, 2002.* 2. *Roger.C. Dugan, Mark.F.McGranagham, Surya Santoso, H.Wayne Beaty, "Electrical Power Systems Quality", McGraw Hill, third edition, 2012.* 3. *J.C.Das," Power System Harmonics and Passive Filter Designs", Wiley-IEEE Press, second edition, 2015.*	4. *Wakileh, George, "Power Systems Harmonics Fundamentals, Analysis and Filter Design", Springer Verlog Berlin Heidelberg, first edition, 2001.* 5. *Lucas Foremann, "Power Quality Monitoring Analysis and Enhancement", Scitus Academics, first edition, 2019.* 6. *www.powerqualityworld.com*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	*20%*	-	*30%*	-
Level 2	*Understand*	*30%*	-	*20%*	-	*30%*	-
Level 3	*Apply*	*20%*	-	*30%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*30%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Sharon Ravichandran, ABB Ltd., Chennai*	1. *Dr. M. Jaya Bharata Reddy, NIT, Trichy*	1. *Mr. D. Ravichandran, SRMIST*
2. *Mr. Sabari Ramanan, Manager, Siemens, Chennai*	2. *Dr. M. Senthil Kumar, NIT Patna*	2. *Dr. R. Sridhar, SRMIST*

Course Code	21EEE303J	Course Name	REAL TIME EDGE COMPUTING IN ENERGY SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the basics of edge computing, hardware in the loop simulation and rapid control prototyping*
CLR-2:	*understand the real time edge monitoring framework and controller development for energy systems*
CLR-3:	*enrich the knowledge of implementing data analytics, deep learning and artificial intelligence in edge computing*
CLR-4:	*deploy coding and sensor integration in onboard processor*
CLR-5:	*enrich knowledge of code optimization and onboard processor deployment for energy systems*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*enumerate the understanding of edge computing, HIL and RCP*	*2*	-	-	-	*2*	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*summarize the edge computing architecture and controller deployment*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*demonstrate the implementation of AI, deep learning and data analytics in processors*	*3*	-	-	-	*2*	-	-	-	-	-	-	*2*	-	*2*	-
CO-4:	*enumerate algorithm prototyping and sensor integration*	*3*	-	-	-	*2*	-	-	-	-	-	-	*2*	-	*2*	-
CO-5:	*develop coding optimization and onboard processor deployment*	*3*	-	-	-	*2*	-	-	-	-	-	-	*2*	-	*2*	-

Unit-1 - Basics of Edge Computing, HIL and RCP — ***12 Hour***

Introduction to computing- Basics: Edge computing, HIL, RCP-Trends in edge computing-Paradigms of edge computing-Edge devices-edge computing-IoT devices, Actuators, Sensors for edge computing.
Laboratory Practice*: sensor integration- monitoring- actuator control*

Unit-2 - Edge Architecture and Controller Deployment — ***12 Hour***

Edge computing framework-Virtualization techniques in edge- Mobile and multi access edge computing-Edge computing for real time monitoring in smart grid-controller deployment in edge devices.
Laboratory Practice*: modeling and control using simulation tool-Code generation for edge computing- Architecture design and implementation of edge based smart grid.*

Unit-3 - Deep Learning and Data Analytics in Edge Devices — ***12 Hour***

AI deployment in embedded systems-Using APPs for AI tasks-Deep learning workflow-Accelerating/Scaling AI workflow using GPUs- Practice: AI deployment in embedded device-AI Edge data analytics- Architecture of edge analytics- Combination of big data and edge data process-Performance evaluation for edge AI
Laboratory Practice*: Data collection and preprocessing- Edge processing for smart grid IoT systems.*

Unit-4 - Algorithm Prototyping and Sensor Integration — ***12 Hour***

CPU, FPGA and I/O solutions for real time simulation- Mobile CPUs and GPUs-FPGA based solutions- CUDA architecture- Practice: CUDA coding- Edge based distributed analytics for reliability and security of smart grid- Real time network protocols for edge computing.
Laboratory Practice: *Interfacing sensors with processors- -Edge enabled advanced metering infrastructure*

Unit-5 - Code Optimization and Processor Deployment	***12 Hour***
Speed Goat/Jetson Nano edge processor-Jetson edge processor-code optimization for edge devices-Broadcast/Deployment on FPGA-Mobile Deployment-Mobile Deployment-Resource scheduling and allocation in embedded real time systems. ***Laboratory Practice:*** *Experimental evaluations and test beds for edge enabled smart grid applications-Edge computing for energy scheduling in microgrid.*	

Learning Resources	1. *Xiaofei Wang, Yiwen Han, Victor C.M.Leung, Dusit Niyato, Xueqiang Yan, Xu Chen, "Edge AI, Convergence of edge computing and artificial intelligence", Springer, first edition, 2020.*	2. *K.Anitha Kumari, G.Sudha Sadasivam, D.Dharani, M.Niranjanamurthy, "Edge computing-Fundamentals", Advances and Applications, CRC Press, first edition, 2021.* 3. *https://in.mathworks.com/help/gpucoder/deployment.html*

Learning Assessment								
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*40%*	-	-	*40%*	*40%*	-
Level 2	*Understand*	*30%*	-	-	*30%*	*30%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Deb Singhdeo, Mathworks*	1. *Dr. N. Vedachalam, NIOT*	1. *Dr. J. Preetha Roselyn, SRMIST*
2. *Mr. Muralikrishnan, Edutech Pvt Ltd*	2. *Dr. Ravikumar Pandi, Amrita Vishwa Vidyapeetham, Kollam*	2. *Dr. K. Vijayakumar, SRMIST*

Course Code	21EEE304T	Course Name	HVDC SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*comprehend the principles of high voltage transmission system*
CLR-2:	*familiarize converter topologies and control of HVDC system*
CLR-3:	*emphasize on harmonics, filters, HVDC faults, and protection*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*distinguish DC and HVDC transmission system*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*illustrate the converter topologies and control employed in the HVDC system*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*discuss harmonics, filters, faults, and protection of the HVDC system*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Introduction to HVDC	***9 Hour***
DC Power transmission technology, Comparison of AC and DC transmission, Description and application of DC transmission system, Comparison of Reliability of DC power Transmission, Need for HVDC system, Evolution and planning for HVDC transmission, Modern trends in HVDC technology, Types and applications of MTDC systems, Global HVDC systems, Case study on HVDC systems in India.	
Unit-2 - Analysis of HVDC Converters	***9 Hour***
Components of HVDC transmission systems, Voltage Source Converters (VSC), VSC HVDC Converter Topologies, Design Graetz circuit with and without overlap, Design Pulse number and choice of converter configuration, Required features of rectification circuits for HVDC transmission, Converter bridge characteristics, Analysis of 12 pulse converters with its different modes of operation, Output voltage waveforms and DC voltage in rectification, DC inverter operation, Equivalent circuit of HVDC link.	
Unit-3 - HVDC System Control	***9 Hour***
HVDC system control features, Principles of DC link control and converter control characteristics, Voltage dependent current order limit and System control hierarchy, Converter Firing Control Schemes, Constant current control and Extinction angle control Power control, Starting and stopping of DC link, Higher level controllers, Control of VSC based HVDC link, Converter malfunctioning.	
Unit-4 - Harmonics and Filter Design	***9 Hour***
Introduction – Generation of harmonics Characteristics harmonics, calculation of AC Harmonics Non- Characteristics harmonics, adverse effects of harmonics, Calculation of voltage and current harmonics, Effect of Pulse number on harmonics, smoothing reactor and DC Lines Reactive power requirements, Harmonic analysis Filter design, Design of AC filters and DC filters, Ratings of filter components and protection of filters, Interference with neighboring communication lines	
Unit-5 - HVDC Fault, Protection and Applications	***9 Hour***
Introduction-DC Faults with Two-Level VSC, Influence of DC Capacitors, Design of VSC Converter, modelling under DC Faults conditions, Advances in HVDC transmission, HVDC Protection, DC Breaker Characteristics and Applications, Basic concepts of DC circuit interruption, VSC HVDC High-Level Controls and AC Grid Support HVDC, Embedded AC Grid, HVDC Connecting Two Separate AC Grids, HVDC in Parallel with a Passive AC System, Design VSC based HVDC with Offshore Wind Farms.	

Learning Resources	1. *K.R. Padiyar, "HVDC Power Transmission System", New Age Intl, third edition, 2015.* 2. *Dragan Jovcic, Khaled Ahmed, "High Voltage Direct Current Transmission: Converters, Systems and DC Grids", Wiley Publishers, first edition, 2015.*	3. *S. Kamkshaiah, V Kamraju, "HVDC transmission", Tata McGraw Hill, second edition, 2021.* 4. *NPTEL: https://nptel.ac.in/courses/108106160.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. K. Boopathi, National Institute of Wind Energy*	1. *Dr. P. Thamizhazhagan, University college of Engineering, Tindivanam.*	1. *Dr. A. Lavanya, SRMIST*
2. *Mr. Jason Manoraj, L&T Technology Services Limited.*	2. *Dr. A. Venkadesan, NIT, Pondicherry.*	2. *Dr. J. Divya Navamani, SRMIST*

Course Code	21EEE305T	Course Name	DESIGN OF ELECTRICAL APPARATUS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	21EEC203J, 21EEC205J	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	enrich the design knowledge on magnetic field and parts of DC machines
CLR-2:	apply the design knowledge of transformers in engineering applications
CLR-3:	analyze the design of stator and rotor of induction machine
CLR-4:	analyze the design knowledge on stator and rotor of synchronous machine

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	acquire knowledge on designing the magnetic fields and parts of DC machines	3	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	explore the knowledge on the design of parts of transformer	3	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	design the stator and rotor of induction machine	3	3	2	-	2	-	-	-	-	-	-	-	2	-	-
CO-4:	design the stator and rotor of synchronous machine	3	3	-	-	-	-	-	-	-	-	-	-	2	-	-

Unit-1 - Basic Design Requirements	**9 Hour**
Design of electrical machines - design factors, design limitations- electrical materials – mmf in air gap and teeth - net iron length and factors – real and apparent flux densities -temperature gradients in core and slots - thermal resistivity of winding.	
Unit-2 - DC Machine	**9 Hour**
Output equation of DC machine – factors for loadings and volume of machine - number of poles and length of air gap – design of armature, pole, commutator and brushes - design problem and analysis.	
Unit-3 - Transformer	**9 Hour**
Overview of transformer types and constructions – kVA rating of transformer – design for optimum, minimum cost and maximum efficiency – design of core, winding - choice of flux density – design of insulations - width of window for optimum output - design of yoke – design of transformer tank with cooling tubes – design problems and analysis	
Unit-4 - Induction Motor	**9 Hour**
Rating of induction motor with design parameters – dimensions of stator – factors for loadings - influence of length of air gap – design of stator – design of squirrel cage rotor end ring - design of wound rotor - design problems and analysis - computer aided design and design practices with software tools for induction motor.	
Unit-5 - Synchronous Machine	**9 Hour**
Dimensions of poles – factors for magnetic and electric loading - runaway speed - main dimensions including pole constructions - short circuit ratio - length of air gap - armature design in synchronous machine - design problems and analysis.	

Learning Resources	
1. *A K Sawhney; A Chakrabarti, "A Course in Electrical Machine Design", Dhanpat Rai and Sons, sixth edition, 2018.*	3. *Sen., S.K., "Principles of Electrical Machine Designs with Computer Programmes", Oxford and IBH Publishing Co. Pvt. Ltd., second edition, 2006.*
2. *Deshpande, M. V., "Design and Testing of Electrical Machine Design", Wheeler Publications, 2010.*	4. *https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-685-electric-machines-fall-2013*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*30%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*30%*	-
Level 3	*Apply*	*30%*	-	*20%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*20%*	-	*10%*	-
Level 5	*Evaluate*	-	-	*20%*	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100%*		*100%*		*100%*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. K.N. Balakrishnan, Magana Automotive India P Ltd.	*1. Dr. K. Udayakumar, College of Engineering, Anna University*	*1. Dr. C. Subramani, SRMIST*
2. Dr. S. Sambath, TANGEDCO	*2. Dr. M. Sudhakaran, Puducherry Technological University, Puducherry*	*2. Dr. Arun Noyal Doss, SRMIST*

Course Code	21EEE306T	Course Name	SPECIAL ELECTRICAL MACHINES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	21EEC203J, 21EEC205J	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	acquire knowledge on stepper motor and its characteristics
CLR-2:	interpret the concepts of switched reluctance motor and its control
CLR-3:	gain knowledge on permanent magnet machines

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	analyze the working and control of stepper motor	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	illustrate the operation and characteristics of switched reluctance motor	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	interpret knowledge on permanent magnet machines	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-

Unit-1 - Stepper Motor	**9 Hour**
Stepper motor - Classification of stepper motor, Modes of Excitation, step angle, Single and Multi-stack stepper motor, Working and its construction, Permanent magnet stepper motor, Torque prediction, Characteristic, Windings, closed loop control schemes, Applications	
Unit-2 - Switched Reluctance Motor	**9 Hour**
Construction and operation, Torque - speed characteristics, Power Semiconductor Switching Circuits, Voltage and Torque equation, Control circuit, Shaft position sensors, Sensor and Sensor-less control, Applications	
Unit-3 - Permanent Magnet Brushless DC Motor	**9 Hour**
Types of BLDC motor based on rotor magnet construction, Characteristic features, electronic commutation in Star and Delta connected stator winding - EMF and Torque Equation - Torque - speed characteristics, Sensor and Sensor-less control, Applications.	
Unit-4 - Permanent Magnet Synchronous Motor	**9 Hour**
Characteristic features, EMF and Torque equation, Torque - speed characteristics, Phasor representation, Power controllers, Digital controllers Sensor and Sensor-less control, Applications	
Unit-5 - Permanent Magnet Axial Flux Machines	**9 Hour**
Construction and operation, Comparison of PM radial and axial flux machines, Armature winding, EMF and Torque equation, Phasor diagram - Output equation - Pulsating torque and its minimisation, Power controllers, Applications	

Learning Resources

1. T.J.E. Miller, "Permanent Magnet and Reluctance Motor Drives", Clarendon Press, Oxford, 1993.
2. T. Kenjo, "Stepping Motors and Their Microprocessor Controls", Clarendon Press, 1995.
3. R. Krishnan, "Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application", CRC Press, 2017.
4. P.P. Acarnley, "Stepping Motors – A Guide to Motor Theory and Practice", Peter Perengrinus, fourth edition 2002.
5. D.P. Kothari and I.J. Nagrath, "Electric Machines", Tata Mc Graw hill publishing company, third edition, 2017.
6. E.G. Janarthanan, "Special Electrical Machines", PHI Learning Private Limited, second edition, 2014.
7. https://www.coursera.org/learn/motors-circuits-design

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Sasikumar Jeyamani, Havells India Ltd	*1. Dr. R. Ramesh, CEG, Anna University*	*1. Dr. M. Arun Noyal Doss, SRMIST*
2. Mr. K.N. Balakrishnan, Magana Automotive India Pvt Ltd	*2. Dr. M. Sudhakaran, Puducherry Technological University, Puducherry*	*2. Dr.K. Mohanraj, SRMIST*

Course Code	21EEE307T	Course Name	ELECTRIC VEHICLE TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the important components of electric vehicles power train*
CLR-2:	*cognize the fundamental of electric vehicles energy storage system*
CLR-3:	*enrich the knowledge of developing electric vehicles power train*
CLR-4:	*understand the dynamics of electric vehicles*
CLR-5:	*familiarize the concept of electric vehicle charging*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the basics of electric vehicles power train*	*3*	-	-	*3*	*2*	-	-	-	-	-	-	-	-	-	*2*
CO-2:	*comprehend the electric vehicles energy storage system*	*3*	-	-	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*
CO-3:	*development of electric vehicles power train and drive subsystems*	*3*	-	-	*3*	*2*	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*modeling electric vehicles dynamics*	*3*	-	-	*3*	*3*	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*study the electric vehicles power train, energy storage system and charging*	*3*	-	-	*3*	*3*	-	-	-	-	-	-	-	*1*	*2*	-

Unit-1 - Fundamental of Electric Vehicles	***9 Hour***
Configuration of Electric Vehicles, Performance of Electric Vehicles, Traction motor characteristics, Vehicle Dynamics and Tractive effort and Transmission requirement, Vehicle performance, Tractive effort in normal driving, Energy consumption, Concept of Electric Vehicles: Electric Drive Trains, Architecture of Electric Vehicles Drive Trains, Study the four-wheel EV Powertrain modelling using the simulation tool.	
Unit-2 - Electric Vehicles Energy Storage System	***9 Hour***
Fundamental approaches to vehicle Energy storage - Energy storage requirements, Battery parameters, Types of Batteries, Modeling of Battery, Types of Battery testing, Types of Fuel Cells, PEMFC and its operation, and Supercapacitors, Battery management systems, Modeling and Simulation of Li-ion Battery Pack Configuration of Electric Vehicles.	
Unit-3 - Design of Electric Vehicles Power Train	***9 Hour***
Electric Plant Subsystem – Electric Drive Train Design: Operating patterns, control strategies, Sizing of major components, power rating of traction motor, Control strategies of drive train, design of electric motor drive capacity, transmission design, energy storage design, Study the HIL Battery Electric Vehicle (BEV) Model for System Level Simulation.	
Unit-4 - Dynamics of Electric Vehicles	***9 Hour***
Basic concept of electric traction, introduction to various electric drivetrain topologies, Motion and Dynamic Equations of the Electric Vehicles: various forces acting on the Vehicle in static and dynamic conditions, Equivalent circuits to represent the dynamic behavior of a battery cell and pack, Study the vehicle dynamics using software simulation.	
Unit-5 - Electric Vehicle Charging	***9 Hour***
Basic understanding of different types of EV Chargers, Electric Vehicle Charging Station Design, Installation- Different modes of EV Charging Infrastructures- Fast Charging and Future Charging- Wireless charging- Smart Charging and V2G, Study the vehicle wireless charger using software simulation.	

Learning Resources	1. *James Larminie, J. Lowry, "Electric Vehicle Technology Explained", John Wiley and Sons Ltd., fourth edition, 2003.* 2. *M. Ehsani, Y. Gao, S. E. Gay, A. Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", CRC Press, second edition, 2004.* 3. *S. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies", Springer, first edition, 2015.* 4. *Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2003.*	5. *Ali Emadi, "Handbook of Automotive Power Electronics and Drives", Taylor & Francis Group, second edition, 2005.* 6. *M. Ehsani, Y. Gao, S. Longo, K. Ebrahim, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles", third edition, 2018.* 7. *Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles- Fundamentals, Theory, and Design", CRC Press, second edition, 2010.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Hariram Satheesh, ABB Limited*	1. *Dr. Sheldon Williamson, Ontario Tech University, Canada*	1. *Dr. C. Bharatiraja, SRMIST*
2. *Dr. Govindaraj, Mahindra Electric*	2. *Dr. Ragavan K, IIT Gandhinagar*	2. *Dr. Ravi Eswar, SRMIST*

Course Code	21EEE308T	Course Name	AUTOMOTIVE ELECTRONICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*enrich the knowledge on the basics of batteries*
CLR-2:	*understand the concepts of battery starting system*
CLR-3:	*introduce the different methods of charging systems for batteries*
CLR-4:	*learn the fundamentals of automotive electronic devices*
CLR-5:	*understand different sensors and actuators used in automotive systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the concept of batteries and it's working*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*1*
CO-2:	*gain knowledge on the concepts of battery starting system*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*1*
CO-3:	*familiarize the principles of charging system for batteries*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*1*
CO-4:	*understand the processes on various controls on electrical vehicles*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*acquire knowledge on sensors and actuators in automotive systems*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	-	-

Unit-1 - Batteries and Lighting Systems — ***9 Hour***

Current trend in Automobiles - Batteries and Accessories, Types of battery - Principle of lead acid battery - construction of lead acid battery - Characteristics of battery - Rating capacity and efficiency of batteries- Various tests on batteries - Visual inspection and voltage testing- Lighting system: insulated and earth return system - Vehicle circuits and systems - Earthling system Types - Head light and side light - LED lighting system- Control of LED lighting system - Horn system- Wiper system and trafficator.

Unit-2 - Starting Systems — ***9 Hour***

Introduction - Starting System - Condition at starting - Behaviour of starter during starting - Advantages and disadvantages - Series motor and its characteristics for starting system - Shunt motor and its characteristics for starting system - Principle and construction of starter motor - Cranking motor construction - Working of different starter drive units - Care and maintenances of starter motor - Starter switches -Optoelectronic devices- solar cells – Photodiodes - Laser Diodes - Light Absorption and Emission - Optical Fiber - Surface-Emitting Lasers - Array Lasers.

Unit-3 - Charging System — ***9 Hour***

Introduction - Charging System - Generation of direct current - Evaluating state of battery health - Fundamental in battery testing - Capacity - Battery testing – internal resistance - Battery testing – self discharging quantity - Factors for degradation and ageing process - Measurement methods of battery - Direct measurement method - Indirect measurement method - Battery Maintenance - New developments on battery charging system - Rate of charging - Depth of charging - Depth of discharging - SoC and SoH - Downfall modes.

Unit-4 - Digital Engine Control System — ***9 Hour***

Fundamentals of Automotive Electronics - Current trends in automotive electronic engine management system - Electric power Braking systems - Electromagnetic interference suppression - Electromagnetic compatibility - Electronic dashboard instruments - Onboard diagnostic system - Security and warning system- -Nano-electromechanical devices - Engine Ignition - Fuel Injection - Collision Avoidance Systems - Safety Controls - Security Alarms - Navigation System - Electronic Control System Diagnostics, OBDII, Diagnostics Fault Codes - Applications of Automotive Electronics - case study.

Unit-5 - Sensors and Actuators	***9 Hour***
introduction - Sensors – Actuators - Types of sensors: sensor for speed - Throttle position - Exhaust oxygen level - Manifold pressure - Crankshaft position - Coolant temperature - Exhaust temperature - Air mass flow for engine application – Solenoids - Various types of electric motors - Piezoelectric force generators - Automatic transmission control systems - Adaptive cruise control, Vehicle stabilization system - Electronic Suspension System - stepper motors - Relays- Types - Thermal Relay – case study.	

Learning Resources		
	1. *William. B. Ribbens, "Understanding Automotive Electronics", Butterworth-Heinemann publications, seventh edition, 2012.* 2. *Tom Denton, "Automobile Electrical and Electronics System", Elsevier, third edition, 2008.* 3. *Judge. A.W., "Modern Electrical Equipment of Automobiles", Chapman and Hall, second edition, 2010.*	4. *Allan. W.M. Bonnick, "Automotive Computer Controlled System", Butterworth-Heinemann, first edition, 2001.* 5. *Vinal. G.W., "Storage Batteries", John Wiley and Sons Inc., fourth edition, 1985.* 6. *Robert Bosch GmbH, "Bosch Automotive Electric and Electronics", Springer-Vieweg, fifth edition, 2007.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	*30%*	-	*30%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Srinivasan Vijayaraghavan, Altair*	1. *Dr. B. Raja, IIITDM, Kancheepuram*	1. *Mr. B. Vinothkumar, SRMIST*
2. *Mr. Sandeep, Mathworks*	2. *Dr. Thanga Raj Chelliah, IIT Roorkee*	2. *Dr. C. Bharatiraja, SRMIST*

Course Code	21EEE309T	Course Name	ENERGY STORAGE SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamentals of energy storage systems*
CLR-2:	*analyze the different types and applications of energy storage systems*
CLR-3:	*understand the battery characteristics and parameters*
CLR-4:	*apply the concept of battery modelling and battery management system*
CLR-5:	*understand battery testing, battery disposal and recycling*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*acquire knowledge on various parts of the energy storage systems and their functions*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*describe discharging and charging process of a lithium-ion battery*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-3:	*analyze the characteristics and parameters of batteries*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-4:	*design the lithium-ion battery packs and battery management system*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-5:	*perform battery testing and recycling of secondary batteries*	*3*	-	-	-	-	-	*2*	-	-	-	-	-	-	-	*2*

Unit-1 - Introduction of Energy Storage ***9 Hour***

History of Energy storage, Energy Storage processes, technologies, and applications, Types of energy storage: Pumped storage, Compressed air, Elevated rail, Flywheels, Liquid air, Thermal, Advanced lead acid, Flow batteries, Lithium-ion batteries. Introduction to lithium-ion battery, Components, functions, advantages and disadvantages of lithium-ion batteries, Growth and development of Li-Ion batteries, charging procedures and charging speed, depth of discharge limitations and cycle lives.

Unit-2 - Li-ion Battery Types and Applications ***9 Hour***

Types of lithium-ion battery: Lithium Cobalt Oxide (LCO), Lithium Iron Phosphate Battery (LFP), Lithium Manganese Oxide (LMO), Lithium Nickel Cobalt Aluminum Oxide (LNCA), Lithium Nickel Manganese Cobalt Oxide (LNMC), Lithium Polymer Battery, Lithium Polymer Battery technology, Difference between the lithium ion and lithium polymer. Applications of Li-ion battery: Battery Requirements- Electrical Requirements, Thermal Requirements, Mechanical Requirements, Automotive Applications- Drive Cycles, SLI (starting, lighting and ignition) batteries, Start-Stop (Micro) Hybrids, Power Assist Hybrids, Plug-In Hybrids, BEVs.

Unit-3 - Battery Characteristics and Parameter ***9 Hour***

Cells and Batteries- conversion of chemical energy to electrical energy- Battery Specifications: Variables to characterize battery operating conditions and Specifications to characterize battery nominal and maximum characteristics; Efficiency of batteries; Heat generation- Battery design, Performance criteria for Electric vehicles batteries- Power and energy requirements of batteries- Battery operating and performance parameters, Charge-discharge characteristics of batteries, Measurement of current, voltage and temperature.

Unit-4 - Battery Modelling and Management Systems ***9 Hour***

General approach to modelling batteries, Selection of battery for EVs & HEVs, Traction Battery Pack design, Requirement of Battery Monitoring, Battery State of Charge Estimation methods, Battery Cell equalization problem, thermal control, Energy & Power estimation, Battery Management System: Definition, Parts: Power Module, Battery, DC/DC Converter, load, communication channel, Battery Pack Safety, Battery Standards & Tests, Cell Balancing: Causes of imbalance, Active Balancing, Passive balancing

Unit-5 - Testing and Recycling of Batteries	***9 Hour***
Battery testing, limitations for transport and storage of cells and batteries, Recycling, disposal and second use of batteries. Battery Leakage: gas generation in batteries, leakage path, leakage rates. Ruptures: Mechanical stress and pressure tolerance of cells, safety vents, Explosions: Causes of battery explosions, explosive process, Thermal Runway: High discharge rates, short circuits, charging and discharging. Environment and Human Health impact assessments of batteries, General recycling issues, methods of recycling of EV batteries.	

Learning Resources	1. *Wu, Yuping, "Lithium-ion Batteries Fundamentals and Applications", CRC Press, Taylor and Francis, first edition, 2015.* 2. *San Ping Jiang, "Fundamentals and Application of Lithium-ion Battery Management in Electric Drive Vehicles", Wiley, first edition, 2015.* 3. *James Larminie, John Lowry, "Electric Vehicle Technology Explained", John Wiley and Sons Ltd, second edition, 2012.*	4. *Ibrahim Dinçer, Halil S. Hamut and Nader Javani, "Thermal Management of Electric Vehicle Battery Systems", John Wiley and Sons Ltd., first edition, 2016.* 5. *Ralph J. Brodd, Masaki Yoshio, Ralph J. Brodd, Akiya Kozawa, "Lithium-Ion Batteries Science and Technologies", Springer, 2009.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Sudharsan, L&T*	1. *Dr. K. Selvajyothi, IIITDM Kancheepuram*	1. *Mr. D. Selvabharathi, SRMIST*
2. *Dr. K. Karthikeyan, ABB India Ltd.*	2. *Dr. Ragavan K., IIT Gandhinagar*	2. *Dr. C. Bharatiraja, SRMIST*

Course Code	21EEE310T	Course Name	ADVANCED DIGITAL SYSTEM DESIGN	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21EEC204J*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*introduce high-level programming language for design of digital circuits*
CLR-2:	*learn techniques and tools for implementation of digital circuits using programmable logic design*
CLR-3:	*explain verification and validation of Verilog implemented circuit*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*acquire knowledge on Verilog synthesis and simulation of digital circuits*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*understand, implement and validate digital circuits using programmable logic devices*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*validate the simulation and design of Verilog programmed circuit*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Digital Design with Verilog ***9 Hour***

Introduction: Design methodology, Simulation, Gate-Level Synthesis, Post synthesis Design Validation and Testing - Structural Models of Combinational Logic - Design Verification and Test Methodology - Models of Combinational and Sequential Logic with Verilog.

Unit-2 - Synthesis of Combinational and Sequential Logic ***9 Hour***

Introduction to synthesis – Synthesis of combinational logic and sequential logic– Synthesis of three-state devices and bus interfaces - Registered logic – State encoding– Anticipating the results of synthesis – Resets – Synthesis of loops – Traps to avoid in design – Divide and Conquer: partitioning a design.

Unit-3 - Design and Synthesis of Data Path Controllers ***9 Hour***

Partitioned sequential machines – Design example: Binary counter – Design and synthesis of a RISC stored-program machine – Processor, ALU, Controller, Instruction Set, Controller Design and Program Execution – UART: Operation, Transmitter, Receiver.

Unit-4 - Programmable Logic Devices ***9 Hour***

Programmable Logic Array (PLA) - Programmable Array Logic (PAL) - Programmability of PLDs - Complex PLDs (CPLDs) - Field-Programmable Gate Arrays - FPGA Technologies - XILINX Virtex FPGAs - Embeddable and Programmable IP Cores for a System-on-a-Chip (SoC) - Verilog-Based Design Flows for FPGAs - Synthesis with FPGAs

Unit-5 - Post Synthesis Design Tasks ***9 Hour***

Post synthesis Design Validation - Post synthesis Timing Verification - Elimination of ASIC Timing Violations - False Paths - System Tasks for Timing Verification - Fault Simulation and Testing - JTAG Ports and Design for Testability

Learning Resources

1. *Michael D. Ciletti, "Advanced Digital Design with the VERILOG HDL", Pearson Education, second edition, 2010.*
2. *Stephen brown, "Fundamentals of Digital Logic with Verilog", McGraw-Hill, third edition, 2014.*
3. *Charles Roth, Lizy Kurian John, ByeongKil Lee, "Digital systems design using Verilog", Cengage Learning, first edition, 2014.*
4. *Samir Palnitkar, "Verilog HDL", Pearson Education, second edition, 2003.*
5. *Steve Kilts, "Advanced FPGA Design: Architecture, Implementation and Optimization", Wiley publication, first edition, 2007.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Bhaskarsahu, Schneider Electric Ltd.	*1. Dr. K. S. Swarup, IIT Madras*	*1. Dr. D. Anitha, SRMIST*
2. Mr. Manikandan P V, Intel Technology India Pvt Ltd	*2. Dr. R. Subha, M S Ramaiah Institute of Technology*	*2. Dr. N. Kalaiarasi, SRMIST*

Course Code	21EEE311T	Course Name	FPGA ARCHITECTURE AND PROGRAMMING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the simple digital systems with programmable logic devices*
CLR-2:	*acquire knowledge in the architecture of FPGAs*
CLR-3:	*understand the design considerations of FPGAs*
CLR-4:	*impart knowledge in design of simple combinational and sequential circuits using FPGAs*
CLR-5:	*explore the various commercial FPGAs features and operations*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*design the simple digital systems with programmable logic devices*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*understand the architecture of various FPGAs*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*analyze the design considerations of FPGAs*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*elucidate the simple combinational and sequential circuits using FPGAs*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*analyze the various commercial FPGAs features and operations*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction to FPGA	***9 Hour***
Digital system design options and tradeoffs, Design methodology and technology overview, High Level System Architecture and Specification: Behavioral modelling and simulation, Hardware description languages (emphasis on Verilog), combinational and sequential design, state machine design, synthesis issues, test benches	
Unit-2 - Programmable Logic Devices	***9 Hour***
ROM, PLA, PAL, CPLD, FPGA Features, Limitations, Architectures and Programming, Implementation of MSI circuits using Programmable logic Devices.	
Unit-3 - FPGA Architecture	***9 Hour***
FPGA Architectural options, granularity of function and wiring resources, coarse V/s fine grained, vendor specific issues (emphasis on Xilinx and Altera), Logic block, architecture: FPGA logic cells, timing models, power dissipation I/O block architecture: Input and Output cell characteristics, clock input, Timing, Power dissipation.	
Unit-4 - Placement and Routing	***9 Hour***
Programmable interconnect - Partitioning and Placement, Routing resources, delays; Applications -Embedded system design using FPGAs, DSP using FPGAs	
Unit-5 - Commercial FPGA'S	***9 Hour***
Xilinx, Altera, Actel (Different series description only), Case study Xilinx Vertex: implementation of simple combinational and sequential circuits.	

Learning Resources		
	1. *Wayne Wolf, Verlag, "FPGA-Based System Design", Prentice Hall, second edition, 2004.*	4 *Pak K. Chan, "Digital System Design Using Field Programmable Gate Arrays", Prentice Hall, third edition, 2009.*
	2. *Wayne Wolf, "Modern VLSI Design: System-on-Chip Design", Prentice Hall, 3rd ed, 2002.*	5 *S.D. Brown, R.J. Francis, J. Rose, Z.G. Vranesic , "Field Programmable Gate Arrays", Springer, second edition, 2007.*
	3. *Stephen M. Trimberger, "Field-Programmable Gate Array Technology", Springer, second edition, 2012.*	

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	*30%*	-	*30%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Ashwin, Qualcomm	*1. Dr. R. Ramesh, CEG Anna University*	*1. Dr. R. Narayanamoorthi, SRMIST*
2. Mr. Vvss Anjaneya Gupta, KPIT technologies	*2. Dr. P. Vanaja Ranjan, CEG Anna University*	*2. Dr. R. Uthra, SRMIST*

Course Code	21EEE312T	Course Name	ADVANCED ELECTRONIC DEVICES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*review various channel MOSFETs and explore the hetero structures in MOSFETs and its relative devices*
CLR-2:	*outline the theory of nano electronics and extend it to real time applications*
CLR-3:	*identify hybrid electronics devices and correlate it with bio electronics*
CLR-4:	*learn basics of microwave integrated circuits*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the hetero structures of MOSFET in various modern electronic equipment*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*articulate various nano electronic based applications*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*relate hybrid electronics with real time bioelectronic devices*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*acquire knowledge on microwave integrated circuits*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Review and Modelling of MOSFET	***9 Hour***
Introduction, review of MESFETs and MOSFETs, mathematical modelling of long channel and short channel MOSFETs, Scaling of MOSFETs.	
Unit-2 - Hetero MOSFETs	***9 Hour***
Hetero structures of MOSFETs, principle and applications, Characteristics of HFET, Leakage current in MOSFET – Cause and effect, Gunn effect, Gunn diode working Characteristics and application, Resonant tunneling devices	
Unit-3 - Nano Electronics	***9 Hour***
Introduction to Nano electronics, structure, characteristics and its relative equations for applications, Envelop function, Excitons in quantum wells, Nano scale Si-MOSFETs, Nano wire MOSFETs.	
Unit-4 - Hybrid Electronics	***9 Hour***
Introduction to hybrid electronics, MOSFET based Bio electronic Devices: Ion sensitive Field Effect Transistor (ISFET), Measurement with ISFETs, Reference Field Effect Transistor (REFET), Trench gate IGBT, Injection enhanced IGBT, Interfacing bio molecules with electronics in real time applications, Biological Field Effect transistor (BIOFET), Real time application of ENFET, BIOFET.	
Unit-5 - Microwave Integrated Circuits	***9 Hour***
Monolithic microwave integrated circuits. RF characteristics. Dynamic and thermal effects, GaAs logic families. Data communication chip sets. Data conversion chip sets. Digital packaging.	

Learning Resources		
	1. *Tsividis Yannis, "Operation and Modeling of the MOS Transistor", Oxford University Press; third revised edition, 2013.*	3. *Pranab Goswami, "Advanced Materials and Techniques for Biosensors and Bioanalytical Applications", Taylor & Francis Group, first edition, 2020.*
	2. *Vladimir V. Mitin, Viatcheslav A. Kochelap, Michael A. Stroscio, "Introduction to Nanoelectronics", Cambridge University Press, first edition, 2008.*	4. *Vinod Kumar Khanna, "Insulated Gate Bipolar Transistor IGBT Theory and Design", IEEE Press, John Wiley and Sons Inc. Publication, 2003.*
		5. *Yasuo Mitsui, "Monolithic Microwave Integrated Circuits", Gordon and Breach Science publishers, first edition, 2007.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Ms. Sweet Annie Grace, ISRO	*1. Dr. K. S. Swarup, IIT Madras*	*1. Dr. Uthra R, SRMIST*
2. Mr. Manikandan P V, Intel Technology India Pvt Ltd	*2. Dr. R. Subha, M S Ramaiah Institute of Technology*	*2. Dr. N.Kalaiarasi, SRMIST*

Course Code	21EEE313T	Course Name	PHOTONICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*relate the basic laws to analyze the light wave propagation*
CLR-2:	*outline the concepts of optic fiber connectors and diagnostics*
CLR-3:	*understand the fundamental mechanisms, frequency conversion methods and electro-optic effects in non-linear optics*
CLR-4:	*compare the different sources of light with its detection systems*
CLR-5:	*explain the various types of laser based on its construction and operation*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the concepts of interaction between light and matter*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*categorize the dispersion in different media and also predict the optic fiber losses by the use of diagnostic methods*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*summarize the concepts of frequency conversion methods and electro-optic effects in non-linear optics*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*distinguish the several light sources and the equipment's implemented to detect the light*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*interpret the type of laser used for specific application in different environmental conditions*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Introduction to Light Propagation	***9 Hour***
Nature of Light – Light at a Boundary – Light passing through Apertures – Imaging optics - Planar waveguides – Waveguide Modes, Mode chart, Dispersion - Cylindrical Waveguides - Acceptance Angle and Numerical Aperture, Cylindrical Waveguide Modes.	
Unit-2 - Losses, Dispersion, Connections and Diagnostics in Fiber Optics	***9 Hour***
Absorption Loss – Scattering and its types – Bending Losses - Graded Index Fiber - Intramodal Dispersion - Waveguide Dispersion - Fiber Connections – Losses in Fiber Connections - Fiber loss diagnostics.	
Unit-3 - Nonlinear Optics	***9 Hour***
Fundamental Mechanisms – Electron Cloud Distortion – Other Non-linear Mechanisms - Frequency Conversion – Non-linear Refractive index - Electro-optic Effects: Pockels Effect, Kerr Effect	
Unit-4 - Light Sources and Optical Detectors	***9 Hour***
The LED - The Laser Diode - Thermal Detectors - Photon Detectors - Noise in Photon Detectors – Photodiode Biasing – Output Saturation – Response Time - Types of Photodiodes - Signal-to-Noise Ratio - Detector Circuits	
Unit-5 - Lasers and Coherent Light	***9 Hour***
Introduction - Laser beam characteristics - Coherence Properties of Laser Light - Different laser systems: Ruby Laser, Neodymium-Based Laser, Titanium Sapphire Laser, He-Ne Laser, Argon Ion Laser, CO2 Laser, Dye Laser, Fiber Laser - Basic Equations for Amplification and Mode Locking in Fiber Lasers.	

Learning Resources	1. *Richard S Quimby, "Photonics and Laser: An Introduction", John Wiley & Sons, first edition, 2006.* 2. *Thyagarajan K, Ajoy Ghatak," Lasers fundamentals and practices", Springer, second edition, 2007.*	3. *Keigo Iizuka, "Elements of Photonics for Fiber and Integrated Optics", Volume II, John Wiley and Sons, first edition, 2002.* 4. *Bahaa E.A. Saleh, Malvin C.T., "Fundamentals of Photonics", John Wiley and Sons, first edition, 2019.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. D. Periasami, Photosonic system Pvt. Ltd., Coimbatore*	1. *Dr. K. Sunil Kumar, IISc, Bengaluru*	1. *Dr. K. Mohanraj, SRMIST*
2. *Mr. Danrajpurkar, Danano Photonics, Bengaluru*	2. *Dr. S. Selladurai, CEG, Anna University*	2. *Dr. M. Arun Noyal Doss, SRMIST*

Course Code	21EEE314T	Course Name	OPTICS FOR ENGINEERS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*provide an understanding of optical principles and analyze the optical systems*
CLR-2:	*outline the concept of electromagnetic optics, polarized light and diffraction*
CLR-3:	*deliver idea about optical wave guides and basics of holography*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the optical systems*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*gain knowledge on electromagnetic optics, polarized light, diffraction and interference*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*advance knowledge on optical wave guides and basics of holography*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Optical Sources and Detectors	***9 Hour***
Introduction to Optical Engineering - Spectrum of optical radiation, Optical units, radiometry and photometry, Detectors of optical radiation - Thermal detectors, Photon detectors and Photo emissive detectors	
Unit-2 - Geometric Optics – Reflection and Refraction	***9 Hour***
Postulates of Geometric Optics - Geometric Optics and Imaging -Fermat's Principle of least time, Snell's Law, Reflected and transmission energy, Refraction and wave fronts, Critical and total internal reflection.	
Unit-3 - Wave Optic	***9 Hour***
Polarized light – optical activity, Fresnel theory, specific rotation, diffraction - Slit diffraction, Condition for first dark, Basics of interference, Interference of light, coherence Double-Slit Interference.	
Unit-4 - Fiber Optics	***9 Hour***
Planar wave guides - Homogenous planar wave guides, Attenuation in waveguides Dispersion, Madal, material, wave guide dispersion, fiber optics Salient features of optical fibers, ray theory of light guidance - modes of a fiber.	
Unit-5 - Holography and Applications	***9 Hour***
Principle of holography, Recording and reconstruction of Image, Application of holography, Optical Data processing - Pattern recognition, Image enhancement, Optical memories	

Learning Resources	
	1. *B.D. Guenther, "Modern Optics", Oxford University Press, second edition, 2015.*
	2. *Charles A. DiMarzio,"Optics for Engineers", CRC Press, first edition, 2011.*
	3. *Z. Malacara, "Handbook of Optical Design", CRC Press, second edition, 2003.*
	4. *Francis T. S. Yu, "Introduction to Optical Engineering", Cambridge University Press, first edition, 1997.*
	5. *Ajoy Ghatak, "Optics", McGraw Hill, seventh edition, 2020.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. M. Lokesh, Digital, Centum Electronics Ltd, Bangalore	*1. Dr. K. S. Swarup, IIT Madras*	*1. Dr. S. Vijayalakshmi, SRMIST*
2. Mr. M. Umasankar, Bharat Electronics Limited, Andhra Pradesh	*2. Dr. Ilavarasan T, VIT, Chennai*	*2. Dr. R. C. Ilambirai, SRMIST*

Course Code	21EEE315T	Course Name	PROGRAMMING FOR ENGINEERS WITH C++	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*commiserate the basics of OOPS*
CLR-2:	*articulate on objects and operator overloading*
CLR-3:	*examine the basics of probabilistic approaches of stack, linked list and memory allocation*
CLR-4:	*acquire knowledge on trees and tree traversal algorithm*
CLR-5:	*examine the sorting and their implementation*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*discuss the basics of OOPS and its approach to design software*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-2:	*execute and implement programs using classes and objects, operator overloading, inheritance and use them in programs*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*construct the concept of stack, link list and memory allocation*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*discuss the terms associated with trees, tree traversal algorithm and trees implementation*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*distinguish the concepts of graph and sorting and their implementation using basic data structure and algorithms*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - OOP Concepts	***9 Hour***
Overview of C++ – Structures – Class Scope and Accessing Class Members – Reference Variables – Constructors – Destructors – Member Functions and Classes – Friend Function – Dynamic Memory Allocation – Static Class Members – Overloading: Function overloading and Operator Overloading	
Unit-2 – Inheritance	***9 Hour***
Base Classes and Derived Classes – Protected Members – Overriding – Public, Protected and Private Inheritance – Constructors and Destructors in derived Classes - Class Object To Base – Class Object Conversion – Composition Vs. Inheritance – Virtual functions – This Pointer – Virtual Destructors – Dynamic Binding	
Unit-3 - Linear Data Structures	***9 Hour***
Abstract Data Types (ADTs) – List ADT – array-based implementation – linked list implementation — singly linked lists –Polynomial Manipulation – Stack ADT – Queue ADT – Evaluating arithmetic expressions. Create a (gallery) image viewer using linked list	
Unit-4 - Non-Linear Data Structures	***9 Hour***
Trees – Binary Trees –Binary tree representation and traversals – AVL Trees - B-Trees - Red - Black Trees - Splay Trees - Application of trees: Set representation and Union-Find operations.	
Unit-5 - Graphs, Sorting and Searching	***9 Hour***
Graph and its representations – Graph Traversals - Breadth-first search – Depth-first search – Topological Sort - Minimum Spanning Trees - Kruskal and Prim Algorithm - Shortest Path algorithm - Sorting algorithms: Insertion sort – Quick sort – Merge sort – Searching: Linear search –Binary Search.	

Learning Resources	1. *Mark Allen Weiss, "Data Structures and Algorithm Analysis in C++", Addison-Wesley, fourth edition, 2014.* 2. *Bhushan Trivedi, "Programming with ANSI C++, A Step-By-Step approach", Oxford University Press, 2010.*	3. *Goodrich, Michael T., Roberto Tamassia, David Mount, "Data Structures and Algorithms in C++", Wiley, seventh edition, 2004.* 4. *Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, "Introduction to Algorithms", Mc Graw Hill, second edition, 2002*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Ms. Kanitha Anand, CTS*	1. *Dr. A. Padmavathi, Amrita Chennai campus*	1. *Dr. K. Saravanan, SRMIST*
2. *Mr. L. Gopikumar, HCL*	2. *Dr. Vairamuthu S, VIT Vellore Campus*	2. *Dr. A. Maheshwari, SRMIST*

Course Code	21EEE316T	Course Name	COMPUTER ORGANIZATION AND ARCHITECTURE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*discuss the functional units and instruction representations required in the computer*
CLR-2:	*articulate on instructions sets and addressing modes*
CLR-3:	*examine arithmetic operations for fixed- and floating-point numbers*
CLR-4:	*acquire knowledge on pipelining and parallel processing*
CLR-5:	*discuss the different types of memory and I/O devices required in the system*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify the different functional units and instruction representations*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-2:	*synthesize instruction sets, formats and addressing modes*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*compute simple arithmetic operations for fixed point and floating-point addition, subtraction, multiplication and division*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*differentiate pipelining, parallel processing, multithreading and multicore processing*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*identify the different types of memory and I/O devices*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Basic Structure of a Computer System	***9 Hour***
Functional Units – Basic Operational Concepts – Performance – Instructions, Computer Language – Operations, Operands – Instruction representation – Logical operations – decision making – MIPS Addressing.	
Unit-2 - Arithmetic for Computers	***9 Hour***
Addition and Subtraction – Multiplication – Division – Floating Point Representation – Floating Point Addition and Multiplication – Sub word Parallelism.	
Unit-3 - Processor and Control Unit	***9 Hour***
A Basic MIPS implementation – Building a Data path – Control Implementation Scheme – Pipelining – Pipelined data path and control – Handling Data Hazards & Control Hazards – Exceptions. ***Project:*** *Design a processor with minimum number of instructions, so that it can do the basic arithmetic and logic operations*	
Unit-4 - Parallelism	***9 Hour***
Parallel processing challenges – Flynn's classification – SISD, MIMD, SIMD, SPMD, and Vector Architectures – Hardware multithreading – Multi-core processors and other Shared Memory Multiprocessors – Introduction to Graphics Processing Units, Clusters, Warehouse Scale Computers and other Message Passing Multiprocessors.	
Unit-5 – Memory and I/O Systems	***9 Hour***
Memory Hierarchy – memory technologies – cache memory – measuring and improving cache performance – virtual memory, TLB's – Accessing I/O Devices – Interrupts – Direct Memory Access – Bus structure – Bus operation – Arbitration – Interface circuits – USB. ***Project:*** *Simulate modern traffic control system*	

Learning Resources	1. *David A. Patterson, John L.Hennessy, "Computer Organization and Design", Morgan Kaufmann Publishers, fifth edition, 2014.* 2. *Carl Hamacher, Zvonko Vranesic, safwat Zaky, "Computer Organization and Embedded Systems", Tata McGraw Hill, sixth edition, 2011.*	3. *William Stallings, "Computer Organization and Architecture", Pearson Education, tenth edition, 2015.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. K. Naveen, Infosys, Chennai*	1. *Dr. Vidyasagar, Amrita University, Chennai campus.*	1. *Dr. K. Saravanan, SRMIST*
2. *Mr. Raman, Calix, Bangalore*	2. *Dr. R. V. Aswiga, VIT, Chennai Campus*	2. *Dr. K. Vijayalakshmi, SRMIST*

Course Code	21EEE317T	Course Name	COMPUTER NETWORKS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify the protocol layering and physical level communication*
CLR-2:	*describe how data link layer protocol and network layer provide services*
CLR-3:	*explain transport layer and application protocols*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*classify different computer network types, layers and switching*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*illustrate the importance of data link and network layer protocols*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*review the protocols used in transport and application layer*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction and Physical Layer	***9 Hour***
Introduction to Computer Networks History, Personal, Local, Metropolitan and Wide Area Networks; Telecommunications and Cellular Networks overview, Layered Network Protocol Architectures; ISO OSI Seven-layer model, Circuit Switching and Packet Switching, 3G,4G technology, Wi-Fi technology	
Unit-2 - Data-Link Layer and Media Access	***9 Hour***
Introduction, Link-Layer Addressing, DLC Services, Data-Link Layer Protocols, HDLC, PPP, Media Access Control, Wired LANs: Ethernet, Wireless LANs, IEEE 802.11, Bluetooth, Connecting Device	
Unit-3 - Network Layer	***9 Hour***
Network Layer Services – Packet switching – Performance – IPV4 Addresses, Forwarding of IP Packets, and Network Layer Protocols: IP, ICMP v4, Unicast Routing Algorithms, Protocols, Multicasting Basics, IPV6 Addressing, and IPV6 Protocol.	
Unit-4 - Transport Layer	***9 Hour***
Introduction – Transport Layer Protocols – Services – Port Numbers – User Datagram Protocol – Transmission Control Protocol – SCTP.	
Unit-5 - Application Layer	***9 Hour***
WWW and HTTP – FTP – Email –Telnet –SSH – DNS – SNMP	

Learning Resources	
	1. *Kurose and Ross, "Computer Networking - A top-down approach", Pearson 7th ed 2017.* 2. *Andrew S. Tanenbaum, "Computer Networks", Pearson Education India, fifth edition, 2013* 3. *Behrouz A. Forouzan, "Data communication and Networking", Mc Graw-Hill, fourth edition.* 4. *William Stalling, "Data and Computer Communications", Pearson Education India, tenth edition, 2017.* 5. *NPTEL: https://nptel.ac.in/courses/106106091*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*30%*	-	*40%*	-	*30%*	-
Level 3	*Apply*	*30%*	-	*40%*	-	*30%*	-
Level 4	*Analyze*	*20%*	-		-	*20%*	-
Level 5	*Evaluate*		-		-		-
Level 6	*Create*		-		-		-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. C. Balasubramanian, SIFY Technologies	*1. Dr. P. Thamizhazhagan, University College of Engineering,Tindivanam*	*1. Dr. A. Lavanya, SRMIST*
2. Mr. Manish Kumar Singh, Tata Consultancy Services	*2. Dr. A. Venkadesan, National Institute of Technology, Pondicherry*	*2. Dr. J. Divya Navamani, SRMIST*

Course Code	21EEE318J	Course Name	INTRODUCTION TO PYTHON PROGRAMMING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*examine the problem-solving techniques using python*
CLR-2:	*analyze the datatypes and control strategies*
CLR-3:	*enrich the knowledge of various functions in python*
CLR-4:	*analyze the exception handling and python MySQL*
CLR-5:	*implement on data handling and interfaces using python*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*enumerate the understanding of algorithmic solutions to computational problems*	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*summarize the different datatypes and control strategies*	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*demonstrate the python programs using conditionals and loops for solving problems*	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-
CO-4:	*formulate python date handling*	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*develop a web-based algorithms in python programs*	2	2	-	-	-	-	-	-	-	-	-	-	-	2	-

Unit-1 - Problem Solving Techniques	***12 Hour***
Computational Problem-Solving, Problem-Solving Techniques: Algorithms, building blocks of algorithms, Pseudo code, Flow chart. ***Laboratory Practice:*** *Mathematical calculator, accept marks and calculate average and grade, Sum of first n even and odd numbers*	
Unit-2 - Introduction to Python and Control Flow	***12 Hour***
Python interpreter and interactive mode; Literals, data types, variables, expressions, statements, operators, comments, Control flow: conditional statements, Iterative statements, control statements, Problems based on conditional statements, Problems based on control statements ***Laboratory Practice:*** *Area of different Shapes, Printing number in words, Calculating Elapsed Days and Time*	
Unit-3 - Functions, Strings and Command Line Arguments	***12 Hour***
Functions: fruitful functions, void functions, Built-in Functions, Strings, Command Line Arguments, Towers of Hanoi using Functions ***Laboratory Practice:*** *Factorial functions, Towers of Hanoi, check given string is palindrome*	
Unit-4 - Advanced Datatypes and Internal Data Handling	***12 Hour***
Lists, Tuples, Dictionaries, Exception handling, Python MySQL ***Laboratory Practice:*** *Number of words, vowels in a paragraph, Sorting, Searching.*	
Unit-5 - External Data Handling and Interfaces	***12 Hour***
Files, Modules, Packages, Case studies: GUI Programming with TKinter, Web-based application, A simple blog, a wiki web. ***Laboratory Practice:*** *Storage and retrieval of Market sales information, Histogram, reading an excel file using python.*	

Learning Resources	1. *Allen B. Downey, "Think Python: How to Think like a Computer Scientist", Updated for Python 3, Shroff/O'Reilly Publishers, second edition, 2016.* 2. *Y.Daniel Liang, "Introduction to Programming using Python", Pearson Education, 1st ed 2017.* 3. *Guido van Rossum and Fred L. Drake Jr, "An Introduction to Python", Revised and updated for Python 3.2, Network Theory Ltd., 2011.*	4. *John V Guttag, "Introduction to Computation and Programming Using Python", Revised and expanded edition, MIT Press, second edition, 2013.* 5. *Robert Sedgewick, Kevin Wayne, Robert Dondero, "Introduction to Programming in Python: An Inter-disciplinary Approach", Pearson India Education Services Pvt. Ltd., first edition, 2016.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. R. Anantha raman, CTS, Chennai*	1. *Dr. A. Prasanna kumar, Amrita Chennai campus*	1. *Dr. K. Saravanan, SRMIST*
2. *Mr. P. Mahesh, TCS, Chennai*	2. *Dr. B. Selvarani, VIT, Vellore*	2. *Dr. U. Sowmmiya, SRMIST*

Course Code	21EEE319T	Course Name	FUNDAMENTALS OF COMPUTATIONAL INTELLIGENCE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*outline the basics of computational intelligence and structure of swarm intelligence optimization techniques*
CLR-2:	*classify the different learning techniques of artificial neural network*
CLR-3:	*demonstrate the concept of evolutionary computation techniques and its applications*
CLR-4:	*gain knowledge on fuzzy logic-based decision-making techniques and its applications*
CLR-5:	*familiarize hybrid intelligence methods to solve optimization problems*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the basics of computational intelligence and examine swarm intelligence concept in engineering optimization problems*	*3*	*2*	*-*	*-*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*
CO-2:	*identify and select suitable artificial neural network learning techniques for engineering problems*	*3*	*2*	*-*	*-*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*
CO-3:	*articulate evolutionary computation techniques to get optimized solution for engineering problems*	*3*	*2*	*-*	*-*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*
CO-4:	*implement fuzzy logic computation approach for decision making problems*	*3*	*2*	*-*	*-*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*
CO-5:	*inculcate with the concept of hybrid intelligence methods to solve engineering problems*	*3*	*2*	*-*	*-*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*

Unit-1 - Introduction to Computational Intelligence and Particle Swarm Intelligence	***9 Hour***
Intelligence - Computational Intelligence – History - Paradigms – Basic particle swarm optimization (PSO) – Global best PSO – Local best PSO – Global vs Local best PSO – Velocity components – Geometric illustration – Ant Colony Optimization-PSO in power system- Algorithm aspects- Examples and Applications	
Unit-2 - Artificial Neural Networks (ANN)	***9 Hour***
Neural network – Biological neuron and Artificial neuron – Activation functions – Characteristics of ANN – ANN Perceptron's – Different ANN Learning techniques- Gradient Descent Learning Rule - Generalized Delta Learning Rule – Exercise solutions.	
Unit-3 - Evolutionary Computation	***9 Hour***
Generic Evolutionary Algorithm – Representation - Initial Population – Fitness function – Selection – Reproduction operators – Stopping conditions - Comparison with traditional optimization methods – Genetic algorithm and programming – binary-coded genetic algorithms - Real coded genetic algorithm-Examples and Applications.	
Unit-4 - Fuzzy Logic	***9 Hour***
Crisp set and Fuzzy set – definition – Membership Functions - Fuzzy Operators - Characteristics - Fuzzy Logic Linguistics Variables and Hedges – Fuzzification – Inferencing – Defuzzification – Fuzzy controller- Exercise solutions - Adaptive neuro-fuzzy inference system - Real time applications	
Unit-5 - Hybrid Intelligent Methods	***9 Hour***
Philosophy of hybrid intelligent systems- classification and architecture of hybrid intelligent- Neuro-Fuzzy Hybrid systems- Neuro Genetic Hybrid Systems-Fuzzy Genetic Hybrid systems- Hybrid Swarm Intelligence Approaches for Optimization- Combined AI-Based Prediction Techniques -Hybrid intelligent techniques for intelligent system control-Performance Analysis of Hybrid Prediction Methods for Load Forecasting – Application of computational intelligent in power engineering.	

Learning Resources	1. *Stuart Russell, Peter Norvig, "Artificial Intelligence: A Modern Approach", Pearson Education, Prentice Hall of India, fourth edition, 2022.* 2. *Elaine Rich and Kevin Knight, "Artificial Intelligence", Tata McGraw-Hill, 3rd ed, 2017*	3. *Patrick H. Winston, "Artificial Intelligence", Pearson Edition, third edition, 2006.* 4. *Dan W. Patterson, "Introduction to Artificial Intelligence and Expert Systems", Prentice-Hall, 1990.* 5. *Nils J. Nilsson, "Artificial Intelligence: a New Synthesis", Elsevier, first edition, 2003.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Arish, PwC AC Bangalore*	1. *Dr. K. Vijayakumar, IIITDM, Kancheepuram*	1. *Dr. C. Naveen, SRMIST*
2. *Mr. S.S.Biswas, Department of Atomic Energy,Bhavini Kalpakkam*	2. *Dr. D.V. Shivakrishna Rao, NIT, Trichy*	2. *Dr. V. Pradeep, SRMIST*

Course Code	21EEE320T	Course Name	NATURE INSPIRED COMPUTING TECHNIQUES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*encapsulate the importance of optimization techniques for engineering problems*
CLR-2:	*elucidate the latest developments in nature-inspired algorithm for several applications*
CLR-3:	*emphasize on the multi-objective problems and its engineering applications*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the better optimization techniques usage for different engineering applications*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*formulate the algorithm for engineering problem using various NIO techniques*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*inculcate the MOOP techniques for engineering application*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	-	-

Unit-1 - Introduction to Computing Optimization ***9 Hour***

Importance of optimization techniques, Search for optimality, Choice of Algorithm, Analysis of optimization Algorithm, Heuristic, hyper heuristic, meta-heuristic algorithm-details and examples, Single objective based met heuristic –trajectory methods, Population based meta-heuristic, Evolutionary computing techniques, Swarm intelligence, Artificial neural network

Unit-2 - Basic - Nature Inspired Optimization ***9 Hour***

Random Walks and Optimization, Optimization as Markov Chains, Step Sizes and Search Efficiency. Modality and Intermittent Search Strategy, Importance of Randomization, Eagle Strategy, Simulated Annealing, SA Algorithm, Basic Convergence Properties, SA Behavior in Practice, Stochastic Tunneling, Genetic Algorithms -Schema Theorem, Convergence Analysis, Differential Evolution, Applications to engineering problems.

Unit-3 - Advance - Nature Inspired Optimization ***9 Hour***

Particle Swarm Optimization Algorithm, Accelerated PSO, Convergence Analysis, Binary PSO, Firefly Algorithms- Firefly Behavior, and Standard Firefly Algorithm, Controlling Randomization, Algorithm Analysis, and Special Cases of FA. Cuckoo Breeding Behavior, Choice of Parameters, Variants of Cuckoo Search, Global Convergence. Bat Algorithms- Echolocation of Bats, Algorithms, Binary Bat Algorithms, Variants of the Bat Algorithm, Convergence Analysis. Flower Pollination Algorithms-Framework for Self-Tuning Algorithms, Application to real time problem.

Unit-4 - Recent Nature Inspired Optimization Algorithms ***9 Hour***

Ant Algorithms- Ant Behavior, Ant Colony Optimization, Virtual Ant Algorithms, Bee-Inspired Algorithms- Honeybee Behavior, Virtual Bee Algorithm, Artificial Bee Colony Optimization Shuffled frog leaping algorithm, Strawberry algorithm, Social Cognitive Optimization, Plant propagation algorithm, Cuttlefish algorithm, Application of optimizations for engineering problems - (Ant colony, Bee inspired, HS, Strawberry

Unit-5 - Multi Objective Optimization ***9 Hour***

Concepts of dominance, Pareto Optimality, Evolutionary algorithm to multi-objective optimization, particle swarm optimization to multi-objective optimization, artificial immune systems to multi-objective optimization, NSGA-II, NPGA, FFGA, CMOP, VEGA, MOPSO, Application of MOO to engineering problems

Learning Resources	1. *Xin-She Yang, "Nature-Inspired Optimization Algorithms", Elsevier Insights, School of Science and Technology Middlesex University London, second edition, 2020.* 2. *Omid Bozorg-Haddad, "Advanced Optimization by Nature-Inspired Algorithms", Studies in computational intelligence, Springer, 2018.*	3. *Anuj Kumar, Sangeeta Pant, Mangey Ram, Om Yadav, "Meta-heuristic Optimization Techniques: Applications in Engineering", De Gruyter series on the application of mathematics engineering and information sciences, 2022.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manikandan P V, Intel Technology India Pvt Ltd.*	1. *Dr. K. S. Swarup, IIT Madras*	1. *Dr. R. Rajarajeswari, SRMIST*
2. *Mr. M Prakash, Edutech*	2. *Dr. P. Somasundaram, CEG, Anna University*	2. *Dr. D. Suchitra, SRMIST*

Course Code	21EEE321T	Course Name	FUNDAMENTALS OF INTERNET OF THINGS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*recognize the design, tier taxonomy, and real-world applications of the IoT*
CLR-2:	*compile programming aspects and develop prototypes of IoT applications*
CLR-3:	*Compare the features and select appropriate devices, and software for an IoT application*
CLR-4:	*analyze on various use cases*
CLR-5:	*categorize the various security requirements and threats to the IoT infrastructure and recommend ways and means to tackle the security challenges*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain the concept of IoT and classify the design elements, protocols, and communication methods*	*2*	-	*1*	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*list the IoT applications, standards and terms governing IoT connectivity and framework*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*apply python programming fundamentals while demonstrating generic design methodology for IoT use cases*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*discriminate between the features of MCUs and develop simple IoT eco-systems*	*3*	-	*2*	-	-	-	-	-	*3*	-	-	-	*3*	-	-
CO-5:	*assess the IoT infrastructure's security concerns and hypothesize on safeguard techniques*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Internet of things (IoT) - Evolution and Generic Design	***9 Hour***
Introduction to the concept-Definition and features-Physical Design-Things-Protocols-Link layer-Internet Layer-Transport Layer-Application layer-Logic Design-Building blocks-IoT communication models-APIs-Technologies-Bluetooth-Zigbee-Wifi-Cellular-LoRa-SigFox-ARM Cortex-Wireless sensor networks- Cloud Vs. Fog Vs Edge-Data analytics-Protocols-Embedded systems-IoT layered architecture templates	
Unit-2 - Connectivity Concepts	***9 Hour***
Applications in general (self-study)-General Standards-Machine to machine (M2M), Device to Device (D2D) integration-M2M Vs IoT- SDN-NFV-UWB-Near field communication-Device management in brief.	
Unit-3 - Design Methodology	***9 Hour***
Specifications in steps for home light automation- Purpose and requirement-Process-Domain Model-Information Model-Service-Level-Functional-Operational- Device Integration-Application development- IoT for weather monitoring (self-study)-Introducing python language in brief – Data types-Data structures-Control flow statements-Functions-Modules – Packages- Classes-Simple programs	
Unit-4 - IoT Devices	***9 Hour***
Mini computers-Arm Cortex- Raspberry PI-Architecture- Interfaces- Programming with python- Interfacing switch and LED- Interfacing LDR- Arduino Uno-Architecture-IDE-Interfacing of sensors and actuators with Arduino- STM32-Architecture- Azure IoT Hub-Middleware- Simple case studies	
Unit-5 - Security, Future in IoT	***9 Hour***
Industrial IoT- AI-ML- Edge computing- Tiny ML-Security measures for IoT ecosystem- Requirements-Authorization-Encryption-Cloud Security-Virtual machine segmentation- Data base segmentation-Virtual machine introspection-Big data security- Security for smart phones- Secure booting-Device authentication-firewalls-Security concerns – Smart transport-Smart grids.	

Learning Resources	1. *Arshdeep Bhaga, Vijay Madisetti, "Internet of Things-A Hands-On Approach", Universities Press Pvt Ltd., second edition, 2016.* 2. *GitHub - arm-university/Internet-of-Things-Education-Kit: Internet of Things Education Kit*	3. *Pethuru Raj, Anupama C Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press, first edition, 2017.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. Bhaskarsahu, Schneider Electric Ltd.*	1. *Dr. A Venkadesan, NIT, Puducherry*	1. *Dr. K. Subha Sharmini, SRMIST*
2. *Ms. Apurva Varma, Academic Engagements, Arm Education*	2. *Dr. A Srinivasan, Agni College of Technology*	2. *Dr. U. Sowmmiya, SRMIST*

Course Code	21EEE322J	Course Name	PROGRAMMABLE LOGIC CONTROLLERS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*able to acquire the basic knowledge of hardware components of PLC*
CLR-2:	*understand the need for programming languages for PLC*
CLR-3:	*identify the applications of timers and counters in process automation*
CLR-4:	*impart knowledge in data manipulation and math instructions in PLC programming*
CLR-5:	*explore the troubleshooting of various types of errors in the programmable logic controller*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*select right I/O modules in PLC for process control applications*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*develop ladder logic program for control applications*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*use timers and counters in process automation applications*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*apply data compare and math instructions using PLC program*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*troubleshoot the input and output malfunctions in PLC*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Introduction to PLC — ***12 Hour***

Evolution of Programmable logic controllers, Architecture of a PLC ,Principles of Operation PLCs versus Computers, PLC size and application, Discrete I/O modules, Sinking and sourcing, Analog I/O modules, Special I/O modules, I/O Specifications, Human Machine Interfaces (HMIs), Alarms, Graphics Library, Developing logic circuit from Boolean expression, Converting Relay Schematics into PLC, Ladder programs, Contractors, switches, Market survey on different PLC's, and its comparison PLC control panel wiring, Basic logic operations.

Laboratory Practice: *Introduction to PLC Wiring, testing of logic functions using PLC, Development of control logic for Material handling system using PLC.*

Unit-2 - PLC Programming and Wiring — ***12 Hour***

PLC programming languages, Instruction and Addressing, Electromagnetic Control Relays Contactors, Switches, Sensor: Proximity Sensor, Magnetic Reed Switch Light Sensors, Velocity Sensors, Output Control Devices-Seal in Circuits, Concerting Relay schematic into PLC ladder programs.

Laboratory Practice: *Demonstration of Traffic light control system, Development of Proximity Sensor Based obstacle detection, Control and test the relay and Contactors function using PLC programming*

Unit-3 - Timers and Counters — ***12 Hour***

Timer Instructions-On-Delay Timer Instruction-Off-delay timer instruction- Retentive Timer -Cascading Timers -Up-Counter- Down Counter -Cascading Counters.

Laboratory Practice: *Development of control logic for Lift control, Development of Temperature control system, DC motor speed control system.*

Unit-4 - Data Manipulation and Math Instructions — ***12 Hour***

Data manipulation- Data transfer operations -Data compare instructions -Data manipulation programs -Numerical Data I/O Interfaces -Math Instructions: Addition Instruction, Subtraction Instruction, Multiplication Instruction, and Division Instruction -Word-Level Math Instruction.

Laboratory Practice: *Electro pneumatic direction control, Development of control logic for Car parking system, Development of control logic for Servo controller.*

Unit-5 – Troubleshooting	***12 Hour***
PLC Enclosures and PLC mounting -Electrical Noise - Leaky Inputs and Outputs- Grounding -Voltage Variations and Surges -Program Editing and Commissioning -Preventive Maintenance- Troubleshooting - Processor Module -Input Malfunctions -Output Malfunctions, Industrial Applications of PLC.	
Laboratory Practice: *PLC Troubleshooting, Development of control logic for Water level control system, Sequence control system for counting*	

Learning Resources	1. *Frank D. Petruzella, "Programmable Logic Controller", Tata McGraw Hill, fifth edition, 2017.* 2. *Bolton. W, "Programmable Logic Controllers", Newnus, Elsevier Newnes, sixth edition, 2016.* 3. *John W. Webb, "Programmable Logic Controllers", Principles and Applications, Prentice Hall, fifth edition, 2011.*	4. *Gary Dunning, "Programmable Logic Controllers", Cengage Learning, third edition, 2009.* 5. *John R. Hackworth, "Programmable logic controllers, Programming Methods and Applications", Pearson, first edition, 2006.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*30%*	*20%*	*-*
Level 2	*Understand*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*20%*	*30%*	*-*
Level 4	*Analyze*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Himanshu Shekhar, L&T Energy*	1. *Dr. Vanaja Ranjan, CEG Anna University*	1. *Dr. A. Dominic Savio, SRMIST*
2. *Mrs. Kala Smile Ross, Dow Chemicals, Chennai*	2. *Dr. E Paul Brinard, IIIT, Chittoor*	2. *Dr. R. Narayanamoorthi, SRMIST*

Course Code	21EEE323T	Course Name	ADVANCED CONTROL SYSTEM	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	21EEC206J	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	develop the state space modelling of different physical system
CLR-2:	analyze the stability of the systems
CLR-3:	apply the concept of state variable design
CLR-4:	develop the PID controller tunning
CLR-5:	analyze the system with external disturbance and sensitivity

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	apply the state space method to model linear and nonlinear system	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	analyze stability of linear and non – linear systems	3	2	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	design pole assignment and state observer using state feedback	3	2	2	-	-	-	-	-	-	-	-	-	2	-	-
CO-4:	solve the PID controller gain by using different types of tuning methods	3	2	2	-	-	-	-	-	-	-	-	-	-	2	-
CO-5:	model the controller by considering external disturbance and sensitivity	3	2	2	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - State Space Modelling of Systems	**9 Hour**
State space modelling of electrical system, mechanical system, fluid system and thermal system for open loop and closed loop analysis.	
Unit-2 - Stability Analysis	**9 Hour**
Stability theory – Stability in state space, Stability analysis by Describing Function Method, Jump Resonance, Signal Stabilization. Lyuopana stability analysis, transient response analysis	
Unit-3 - State Feedback Control	**9 Hour**
Introduction – State Feedback and pole placement - Topology for pole placement, tracking with feedforward controller, Integral control –Controller Design - Observer Design – Reduced order Observer Design, Tracking PI Controller Design – Design example.	
Unit-4 - PID Controller Tuning	**9 Hour**
PID tuning, Modified PID control scheme, Two-Degrees-of-Freedom Control, zero-placement approach to improve response characteristics, PID Control of High-order Systems.	
Unit-5 - Control-Ratio Modeling and Parameter Sensitivity	**9 Hour**
Introduction of control ratio modelling, Guillemin–Truxal Design, Disturbance-Rejection Model, Controller design with parameter sensitivity.	

Learning Resources	
	1. Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall, fifth edition, 2017. 2. M. Gopal, "Modern Control System Theory", New Age International, third edition, 2014. 3. Marquez Horacio J Marquez, "Nonlinear Control Systems: Analysis and Design", Wiley Publications, second edition, 2012. 4. Zoran Vukic, Ljubomir Kuljaca, Dali Donlagic, Sejid Tesnjak, "Nonlinear Control Systems", Marcel Dekker Inc, first edition, 2007. 5. Richard C.Dorf, Robert H.Bishop, "Modern control system theory", Pearson Education Ltd, thirteenth edition, 2016. 6. Online course material: Plat form- NPTEL, Author – Prof. Yogesh Vijay Hote, IIT Roorkee, Web link: https://nptel.ac.in/courses/108107115

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*15%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*15%*	-	*20%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	*10%*	-	*15%*	-	*10%*	-
Level 6	*Create*	*10%*	-	*15%*	-	*10%*	-
	Total	*100%*		*100%*		*100%*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. M. Sendhil, BHEL, Trichy*	1. *Dr. A. Venkatesan, National Institute of Technology, Karaikal*	1. *Dr. A Sureshkumar, SRMIST*
2. *Mr. R. Kalidoss, TANGEDCO, Trichy*	2. *Dr. Lakshmi Sutha G, National Institute of Technology, Puduchery, Karaikal*	2. *Dr. R. Narayanamoorthi, SRMIST*

Course Code	21EEE324T	Course Name	SMART SENSOR SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*acquire knowledge on various characteristics of sensor systems*
CLR-2:	*learn about the different manufacturing techniques of microsensors*
CLR-3:	*focus on new trends and developments such as miniaturized devices, wireless communications and function of different sensors*
CLR-4:	*gain a comprehensive knowledge on smart sensors development and interface details*
CLR-5:	*exposure of latest trends in sensor technologies including multisensor data fusion*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the sensor characteristics and its suitability for a particular application*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*acquire a comprehensive knowledge of manufacturing techniques and design aspects of micro sensors*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*elicit the concepts of wireless sensing techniques and integration to make a smart sensor*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*understand the principle and operation of different smart sensors and their applications*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*get exposure to latest sensor technology and advanced measurement techniques*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	-

Unit-1 - Introduction to Smart Sensors ***9 Hour***

Definitions of Sensors and Smart sensors- General concepts and terminology of Sensor systems -Smart Sensors and Applications-Sensor's classifications -Measurements-Unit of Measurements-Sensor Characteristics: Transfer Function-Calibration, Static Characteristics, Accuracy, Calibration Error, Hysteresis, Nonlinearity, Resolution - Dynamic Characteristics-Physical principles of sensing.

Unit-2 - Sensor Technologies ***9 Hour***

MEMS sensor, Comparison between MEMS and Macro sensor, Fabrication and packaging issue in sensor design, thick film and thin film technique -Physical sensors. Bio sensor types and applications, Silicon sensor principle and application, RF Sensor principle and application, Application of sensors in robotic- Electro chemical sensors

Unit-3 - Wireless Sensing Techniques ***9 Hour***

Wireless Sensor-principle and working-wireless sensing network, protocols used in WSN, Application of wireless sensor for weather monitoring- Sensor arrays - Sensor network - multisensor data fusion - Soft sensor.

Unit-4 - Integrated Smart Sensors ***9 Hour***

Definition –sensing elements –design of Interface electronics - parasitic effects – sensor linearization - Dynamic range - Universal Sensor Interface - front end circuits - DAQ – Design – Digital conversion - Microcontrollers and digital signal processors for smart sensors – selection criteria - Standards for smart sensor interface

Unit-5 - Smart Sensors and Applications ***9 Hour***

Applications of Integrated and Smart sensors, Overview of various smart sensors: Digital temperature sensor (DS1621, TMP36GZ), Humidity sensor, IR sensor, Gas sensor, Pressure sensors, Accelerometer-Structural health monitoring sensors, Flexible sensors.

Learning Resources	1. *Ernest O Doebelin, Dhanesh N Manik, "Measurement Systems Application and Design", Tata Mc-Graw Hill, seventh edition, 2019.* 2. *Gerord C.M. Meijer, "Smart Sensor Systems", John Wiley and Sons, first edition, 2014.*	3. *D. Patranabis, "Sensors and Transducers", PHI, second edition, 2004.* 4. *O.N. Pandey, "Sensors and Instrumentation", S.K Kataria and sons, first edition, 2013.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*15%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*15%*	*-*	*20%*	*-*
Level 3	*Apply*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 4	*Analyze*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 5	*Evaluate*	*10%*	*-*	*15%*	*-*	*10%*	*-*
Level 6	*Create*	*10%*	*-*	*15%*	*-*	*10%*	*-*
	Total	*100%*		*100%*		*100%*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. C. Renga Ramanujan, Hitachi Energy, Chennai*	1. *Dr. Suhana Mohd Said, University of Malaya, Malaysia*	1. *Dr. S. Lourdu Jame, SRMIST*
2. *Dr. Sharmila Devi, Vestas Technology, Chennai*	2. *Dr. K. Nageswari, IIT Bombay*	2. *Dr. R. Narayanamoorthi, SRMIST*

Course Code	21EEE325T	Course Name	FUNDAMENTALS OF ROBOTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*familiarize with the concepts and terminologies of fundamental robotics system*
CLR-2:	*gain knowledge on peripheral devices used in robotics*
CLR-3:	*understand the types of drives, actuators and controls*
CLR-4:	*learning types of robotic programming required for robotics*
CLR-5:	*get insight in various recent robotic applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*interpret terminologies related to robotics technology*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*understand various peripheral devices such as grippers and sensors for robotics*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*select an appropriate drive, actuators and their control system for a specific robotic application*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*write a program for a simple robotic subsystem*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*perform a case study on the recent applications*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Introduction to Robotics	***9 Hour***
Introduction to robots, Brief History, Laws of robots, Components, characteristics and specifications of robot, Terminology and concepts used in robot, Anatomy of Robots, Robot wrist mechanism, Configurations based on coordinate systems-cartesian, cylinder, polar and articulate Configurations based on method of control.	
Unit-2 - Sensors and Grippers for Robotics (Peripheral Devices)	***9 Hour***
Sensors in robotics, Types of sensors-External sensors and Internal sensors, Compliance Sensors, Slip Sensors, Camera, Gripper and its Classification, Gripping mechanism, Guidelines for design of robotic gripper.	
Unit-3 - Drives and Controls	***9 Hour***
Introduction to drives, Types of Drives, Actuator and its principle, selection factors for actuators, Electrical actuators-DC and BLDC motor drives, Stepper motor drives and Servo motor drives for robotic applications, Control Systems: Types of Controllers, PI, PID, sliding mode, model predictive, etc. with an application, Case study on various closed loop control of a robot.	
Unit-4 - Robot Programming	***9 Hour***
Introduction, Programming Techniques, Online Programming, Lead-Through Programming, Walk-Through Programming or Teaching, Offline Programming, Task Level Programming, Motion Programming, Overview of Robot Programming Languages, Types of Robot Languages: VAL, RAIL, AML, Python and ROS, Case study on robot program languages - WAVE till ROS.	
Unit-5 - Applications and Case Studies	***9 Hour***
Various Applications of robots, medical applications, Entertainment, Autonomous/ self-driving vehicles, Arial/Space applications, Underwater/surface applications, Defense applications, Disaster management, Future Applications- case study.	

Learning Resources	1. *D K Pratihar, "Fundamentals of Robotics", Narosa Publishing House Pvt. Ltd., first edition, 2017.* 2. *Jisu Elsa Jacob, Manjunath N, "Robotics Simplified: An Illustrative Guide to Learn Fundamentals of Robotics, Including Kinematics, Motion Control, and Trajectory Planning", BPB Publications, first edition, 2022.*	3. *Hegde, Ganesh S., "A Textbook of Industrial Robotics", Laxmi Publications, first edition, 2006.* 4. *Mikell P. Groover, Mitchell Weiss, Roger Nagel, Nicholas G. Odrey, "Industrial Robotics: Technology, Programming and Applications", McGraw-Hill, first edition, 2012.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*15%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*15%*	*-*	*20%*	*-*
Level 3	*Apply*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 4	*Analyze*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 5	*Evaluate*	*10%*	*-*	*15%*	*-*	*10%*	*-*
Level 6	*Create*	*10%*	*-*	*15%*	*-*	*10%*	*-*
	Total	*100%*		*100%*		*100%*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Balaji Kuppusamy, Mechatriks Industrial Services Pvt Ltd (OPC), Chennai*	1. *Dr. S. Senthil Kumar, NIT, Trichy*	1. *Dr. C. Balaji, SRMIST*
2. *Mr. Saikumar Bairabathina, Valeo India Private Limited, Chennai*	2. *Dr. E. Paul Brinard, IIIT, Chittoor*	2. *Dr. A. Dominic Savio, SRMIST*

Course Code	21EEE326T	Course Name	COMPUTER VISION SYSTEM	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*gain knowledge and understanding about the formation of digital images and its processing*
CLR-2:	*understand the techniques to extract and segment features from the images*
CLR-3:	*analyze and estimate the depth in the images and understand the techniques for object detection*
CLR-4:	*understand the motion analysis techniques for computer vision*
CLR-5:	*impart knowledge on the implementation of various algorithms for applications in computer vision*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explore the basic concepts of image processing and computer vision*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*interpret the ideas about the image segmentation and feature based alignment*	*3*	-	-		-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*acquire knowledge on image detection and matching*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*analyze the various types of motion analysis*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*gain knowledge in image stitching and recognition*	*3*	*1*	-	-	*2*	-	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction to Computer Vision	***9 Hour***
Human Vision System- Computer Vision System -Image formation -Geometric primitives and transformations - Photometric image formation - digital camera- Image processing – Point operators - Linear filtering - More neighborhood operators -Fourier transforms - Pyramids and wavelets - Geometric transformations - Global optimization.	
Unit-2 - Image Segmentation	***9 Hour***
Segmentation: Active contours - Split and merge - Mean shift and mode finding - Normalized cuts -Graph cuts and energy-based methods - Feature-based alignment - 2D and 3D feature-based alignment - Pose estimation -Geometric intrinsic calibration	
Unit-3 - Image Detection and Matching	***9 Hour***
Points and patches -Feature Matching-Application: Performance driven Animation -Edges-Edge detection – Edge linking -Lines – Hough transform- Vanishing points –Rectangle detection	
Unit-4 - Structure from Motion	***9 Hour***
Triangulation - Two-frame structure from motion – Factorization - Bundle adjustment - Constrained structure and motion- introduction to motion –Dens motion estimation-Translational alignment – Parametric motion – Spline-based motion – Optical flow – Layered motion	
Unit-5 - Image Stitching and Recognition	***9 Hour***
Motion models -Global alignment- Face detection- Pedestrian detection – Face recognition –Instance recognition- Category recognition - Recognition with segmentation – Learning and large image collections	

Learning Resources	1. *Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer, second edition, 2010.* 2. *Simon J. D. Prince, "Computer Vision: Models, Learning, and Inference", Cambridge University Press, first edition, 2012.* 3. *E.R. Davies, "Computer and Machine vision: Theory Algorithms Practicalities", Academic Press, Elsevier, fourth edition, 2006.*	4. *Richard Hartley, Andrew Zisserman, "Multiple view geometry in computer vision", Cambridge University press, second edition, 2015.* 5. *Mark Nixon, Alberto S. Aguado, "Feature Extraction & Image Processing for Computer Vision", Academic Press, third edition, 2012.* 6. *D. Forsyth, J. Ponce, "Computer Vision - A modern approach", Pearson Education, second edition, 2012*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. K. Prabhakaran, NIOT, Chennai*	1. *Dr. J. Prakash, MIT, Chennai*	1. *Dr. R. Senthil Kumar, SRMIST*
2. *Dr. R. Vijayarajeswaran, VI Microsystems Pvt. Ltd*	2. *Dr. O. Uma Maheswari, CEG Anna University*	2. *Dr. R. Narayanamoorthi, SRMIST*

Course Code	21EEE327T	Course Name	SUSTAINABLE DEVELOPMENT GOALS AND POLICIES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*recognize the impact of sustainable development*
CLR-2:	*familiarize the government policy required to meet the global goals*
CLR-3:	*identify the role of stake holder for the progress of global goals*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*acquire knowledge on scope and establishment of sustainable development*	*2*	-	-	-	-	-	*3*	*2*	-	-	-	-	-	-	*2*
CO-2:	*outline the framework of sustainable policy needed to achieve global goals*	*2*	-	-	-	-		*3*	*2*	-	-	-	-	-	-	*2*
CO-3:	*elucidate the responsibility of civil society and business sector in advancing the global development*	-	-	-	-	-	*3*	*3*	-	-	-	-	-	-	-	*2*

Unit-1 - Sustainable Development	***9 Hour***
Key Challenges and Policy Responses - Important elements of sustainable development policies - The social dimension - Global temperatures and emissions of greenhouse gases - Sustainable development policies - Managing linkages: global economy, climate change and natural resources - Harnessing science and technology - Design for sustainability: Thinking Alternatives and Innovation.	
Unit-2 - Sustainable Development as a Global Goal	***9 Hour***
Concept of Sustainability: roots, history of development - SDGs: Scale and Scope, Framework, Transformation Challenges, Differential Diagnosis - Structures of power and decision making - international agreements - Transformation Pathways to Success: Education, Inclusion, Jobs, and Growth, Health and Wellbeing, Clean Energy and Industry, Sustainable Food and Land Use - Smart Cities and Transport, Digital Technologies and E-Governance.	
Unit-3 - SDGs Government Policy	***9 Hour***
Planning and Back-casting - Government Organization - Policy Instruments, SDG Pathways: The Case of Deep Decarbonization, Industrial Policies, Financing - Assessments: Estimating Resource, Types of Financing, Capital Markets - New financing mechanisms and Global Funds, Financial Development for the SDGs.	
Unit-4 - Role of SDGs in Business Sector and Civil Society	***9 Hour***
The Role of Business in the SDGs: Shareholders and Stakeholders, Global Value Chains, Unsustainable Industries - Public awareness and Consumer Activism - Data Accountability and Decision making - Investor Activism - Public-Private-Civil Society Partnerships: Litigation and Human Rights, Social business – Role of Central Statistics Office in conflict zones and refugee camps - Circular economy	
Unit-5 - Global Partnership	***9 Hour***
Development Assistance - Dimensions of Global Partnership: Role of Universities and Sustainable Development Solutions Network, Moral Advocacy: Religious Leaders, Cross-Border Cooperation - The World in 2030: Mapping a path forward	

Learning Resources	1. *Hazra, Somnath. Bhukta, Anindya, "Sustainable Development Goals: An Indian Perspective", Springer International Publishing, first edition, 2020.* 2. *Ziai, Aram, "Development Discourse and Global History from colonialism to the sustainable development goals", Routledge, first edition, 2016.* 3. *OECD, "Sustainable Results in Development: Using the SDGs for Shared Results and Impact", OECD Publishing, 2019, https://doi.org/10.1787/368cf8b4-en.*	4. *Sachs, J., Schmidt-Traub, G., Kroll, C., Lafortune, G., Fuller, G., Woelm, F., "The Sustainable Development Goals and COVID-19, Sustainable Development Report 2020, Cambridge University Press, first edition, 2020.* 5. *Organisation for Economic Co-operation and Development, "Sustainable development: critical issues", OECD, 2001.* 6. *https://www.un.org/sustainabledevelopment/*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*50%*	*-*	*30%*	*-*	*50%*	*-*
Level 2	*Understand*	*50%*	*-*	*30%*	*-*	*50%*	*-*
Level 3	*Apply*	*-*	*-*	*20%*	*-*	*-*	*-*
Level 4	*Analyze*	*-*	*-*	*20%*	*-*	*-*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Siddharth S, Renault Nissan Technology and Business Centre India Pvt. Ltd.*	1. *Dr. M. Senthil Kumar, NIT Patna*	1. *Dr. R. Ramya, SRMIST*
2. *Mr. Gowtham K J, Tata Engineering Services*	2. *Ms. C. Santhiya, Thiagarajar College of Engineering, Madurai*	2. *Dr. V. Pradeep, SRMIST*

Course Code	21EEE328T	Course Name	ELECTRICITY POLICY AND SAFETY MEASURES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*recognize the regulatory body for electricity safety and policy*
CLR-2:	*enforce the safety aspects in electrical equipment*
CLR-3:	*perform the safety practices in industrial environment*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*outline the requirement of electricity policy, safety codes and standards*	*2*	-	-	-	-	*2*	-	*3*	*2*	-	-	*3*	-	-	-
CO-2:	*study the safety requirement on various electrical equipment*	*2*	-	-	-	-	*2*	*2*	*3*	-	-	-	*2*	-	-	*3*
CO-3:	*understand the various safety procedures in electrical system*	*3*	-	-	-	-	*2*	-	*3*	-	-	-	*2*	-	-	*3*

Unit-1 - Electricity Policy Requirement ***9 Hour***

Energy and Policy - Energy Scenario of different sectors: Indian and International Level – Global market outlook - Energy Conservation Act 2001 and amendments - Energy Security - Energy Regulations in Indian Power Sector - Structure of Indian Power Sector - Retail Competition.

Unit-2 - National Electricity Policy ***9 Hour***

Tariff Regulations - Role of State/Central Regulatory Commissions – Tariff Policy - Understanding tariff order - Renewable Energy Policy - Incentives and subsidies - Role of MNES, IREDA - Bio Energy Policy - Solar Policy - National Solar Mission - Waste Management Practices and policies - Renewable purchase obligations - National policy on Hydropower - EV Policy - Climate Change Policies - International Environmental Policy Practices

Unit-3 - Electrical Regulatory and Safety ***9 Hour***

The Regulatory Bodies - The National Electrical Safety Code (NESC) – Indian Electricity Grid Code - Indian Electricity rules – Standards for electrical safety - Aspects of Electrical Trauma - Electrical Safety management system – Safety Audits.

Unit-4 - Electrical Safety Equipment and Maintenance ***9 Hour***

Inspection and Testing Requirements - Thermal Protection - Insulating Equipment - Safety Tags, Locks, and Locking Devices – Low voltage / Medium Voltage / High voltage safety equipment – Safety Maintenance program.

Unit-5 - Electrical Safety Procedures and Measures ***9 Hour***

Safety methods – The Six-Step safety method – Safe Switching - Energy control program – Safety grounding procedures – System grounding – Equipment grounding - General safety requirement for electric vehicle charging stations.

Learning Resources

1. *Timothy Braun, Lisa Glidden, "Understanding Energy and Energy Policy", Bloomsbury Publishing, first edition, 2014.*
2. *John Cadick, Mary Capelli-Schellpfeffer, Dennis K. Neitzel, Al Winfield, "Electrical Safety Handbook", McGraw-Hill, fourth edition, 2012.*
3. *Power Engineer's Handbook, TNEB Engineer's Association, sixth edition, 2011.*
4. *Sanjeev Ahluwalia, "Special report on National Electricity Policy 2021: Making India's Power Sector Future-Ready", 2021.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*50%*	-	*30%*	-	*50%*	-
Level 2	*Understand*	*50%*	-	*30%*	-	*50%*	-
Level 3	*Apply*	-	-	*20%*	-	-	-
Level 4	*Analyze*	-	-	*20%*	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. R. Paneerselvam, Retd S.E/south / TANGEDCO – GM, IHPC*	1. *Dr. M. Senthil Kumar, NIT Patna*	1. *Dr. R. Ramya, SRMIST*
2. *Mr. Siddharth S, Renault Nissan Technology and Business Centre India Pvt. Ltd.*	2. *Dr. K. Selvi, Thiagarajar College of Engineering*	2. *Mr. D. Ravichandran, SRMIST*

Course Code	21EEE329T	Course Name	WORK AND EMPLOYABILITY FOR A SUSTAINABLE FUTURE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*acquire knowledge about global perspectives on changes to formal employment*
CLR-2:	*describe the challenges of work for better employment*
CLR-3:	*infer the framework of managing the challenges towards sustainable future*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*illustrate the infrastructure of the employment*	*2*	-	-	-	-	-	*3*	-	-	-	-	*2*	-	-	*2*
CO-2:	*explain the social challenges of the employment*	*2*	-	-	-	-	-	*3*	-	-	-	-	*2*	-	-	*2*
CO-3:	*outline the effective management of income and policies*	*2*	-	-	-	-	-	*3*	-	-	-	-	*2*	-	-	*2*

Unit-1 - Work, Change and Workers	***9 Hour***
Introduction- contemporary accounts of work life - qualities and benefits of working life - subjective accounts of work life - work and sense of self - changing work and its impacts - interdependency between affordances and agency - understanding work and workers - work as relational interdependence.	
Unit-2 - Cultural, Situational and Individual Geneses of Work Life	***9 Hour***
Cultural and situational geneses of work knowledge - sources of changes to work life requirements - perspectives of understanding work performance - complementarities between the social and cognitive contributions - cultural, situational and individual geneses of work life.	
Unit-3 - Relational Basis for Understanding Work Life	***9 Hour***
Relational interdependence between social and individual agency - re-engaging the individual - negotiating between objective and subjective accounts - workplace participatory practices - convergence of thinking, learning and remaking practice - salience of the self - workplace transformations - a relational way of understanding work.	
Unit-4 - Sustainable Development and Decent Work	***9 Hour***
Sustainable development and decent work: Environmental challenges, social challenges and economic instability - labor market dynamics of greening economies: Green jobs creation, employment and income effects - Creating green jobs - Seizing the opportunities: Lessons from international experience - Evidence of the positive employment effects from green policies.	
Unit-5 - Identifying and Managing the Challenges	***9 Hour***
Economic restructuring: Climate change adaptation and the world of work - Adverse income distribution effects originating from energy poverty - Effective policies and the scope for a supportive role by the ILO: Initiatives to promote environmental sustainability and decent work - ILO support for environmentally sustainable development - Coherent policies for more and better jobs in a greener economy - Towards a policy framework for sustainable development, decent and green jobs.	

Learning Resources	1. *Stephen Billett, "Work, Change and Workers," Springer, 2006.* 2. *Report by green jobs initiative,"Working towards sustainable development: opportunities for decent work and social inclusion in a green economy", International Labour Office, 2012.* 3. *International Labour Office, Geneva, "Sustainable development, decent work and green jobs", Switzerland, first edition, 2013.*	4. *Gim Cassio and Alice Rush, "Green Energy Careers: Choosing work for a sustainable future", New Society Publishers, 2009.* 5. *Peter Poschen, "Decent Work, Green Jobs and the Sustainable Economy", Greenleaf Publishing Book, first edition, 2015.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*40%*	-	*40%*	-	*40%*	-
Level 2	*Understand*	*40%*	-	*40%*	-	*40%*	-
Level 3	*Apply*	*10%*	-	*10%*	-	*10%*	-
Level 4	*Analyze*	*10%*	-	*10%*	-	*10%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Bhaskarsahu, Schneider Electric Ltd.*	1. *Dr. K. S. Swarup, IIT Madras*	1. *Dr. M. Sadees SRMIST*
2. *Mr. N. Saravanan, L & T, Chennai*	2. *Dr. M. Senthil Kumar, NIT Patna*	2. *Dr. R. Ramya, SRMIST*

Course Code	21EEE330T	Course Name	NATURAL RESOURCES FOR SUSTAINABLE DEVELOPMENT	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*outline the basics of solar energy*
CLR-2:	*develop the knowledge in wind energy conversion system*
CLR-3:	*understand the energy generation by biomass*
CLR-4:	*familiarize knowledge on ocean and tidal energy*
CLR-5:	*develop knowledge in fuel cell and its types*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*obtain in depth knowledge on solar PV system*	*3*	-	-	-	-	-	*3*	-	-	-	-	*2*	-	-	*2*
CO-2:	*explain the concepts of wind energy conversion systems and their control*	*3*	-	-	-	-	-	*3*	-	-	-	-	*2*	-	-	*2*
CO-3:	*summarize the biomass technologies for energy generation*	*3*	-	-	-	-	-	*3*	-	-	-	-	*2*	-	-	*2*
CO-4:	*analyze the environmental impacts of ocean and tidal energy*	*3*	-	-	-	-	-	*3*	-	-	-	-	*2*	-	-	*2*
CO-5:	*summarize the working principle of fuels cells and its types*	*3*	-	-	-	-	-	*3*	-	-	-	-	*2*	-	-	*2*

Unit-1 - Solar Energy	***9 Hour***
An introduction to energy sources-Energy consumption as a measure of prosperity-World Energy Future- Solar radiation and its Measurements-Solar Energy Collectors-Flat plate collectors, concentrating collectors-Storage of solar energy-Solar pond-Applications of solar Energy -Photo voltaic. Types of PV cells-Characteristics and working principles of PV-Maximum power point tracking methods-Net metering concepts.	
Unit-2 - Wind Energy	***9 Hour***
Introduction- Basic Principles of Wind energy conversion-Wind data and energy estimation- wind speed monitoring-Site Selection-Wind energy conversion system-Wind Energy collectors--Tip Speed Ratio-Solidity-Types of generators and power converters in WECS-Control schemes for power converters-Introduction to grid integration of WECS-Issues in grid integration	
Unit-3 - Biomass	***9 Hour***
Introduction-Biomass Conversion Technologies- Photosynthesis-Pyrolysis- Energy Forming-Factors affecting digestion system-Classification of biogas plants-Advantages and disadvantages of biogas plants - Site Selection-Digester design considerations-Community Gas Plant-Types of Biomasses Fuels-Biomass power plant-Biomass cogeneration	
Unit-4 - Ocean Thermal Energy Conversion (OTEC) Systems	***9 Hour***
Principle of OTEC-OTEC power plant-Open loop system for ocean energy conversion-Closed loop system for ocean energy conversion-Single basin-dual basin ocean energy conversion system-Major problems and operational experience Tidal energy-Site selection of tidal power plant-Tide ,Spring tide-Neap tide, Tidal range-Types of Tidal power plant-Advantages and disadvantages of tidal power plant-Wave Energy-Wave Characteristics-Different wave energy convertors, Salter Duck-Oscillating water column and dolphin types.	
Unit-5 - Electrochemical Energy Sources	***9 Hour***
Introduction –Design and Principle of operation of a fuel cell-Classifications of fuel cell-Types of fuel cells-Advantages and Disadvantages-Conversion Efficiency of fuel cell-Types of Electrodes-Applications of a fuel cells-batteries for storage-basic battery theory-Definition of fundamental quantities-battery fundamental characteristics-Different types of battery arrangement-Classification-Advantages of batteries for bulk energy storage.	

Learning Resources	1. Rai,G.D., "Non-Conventional sources of Energy", Khanna Publishers, fifth edition 2016. 2. Khan. B.H, "Non-Conventional Energy Resources", The McGraw Hills, second edition, 2016. 3. O'Hayre, R.P.S. Cha, W. Colella, F.B.Prinz, "Fuel Cell Fundamentals", Wiley, third edition, 2016.	4. S. N. Bhadra, D. Kastha, S. Banerjee, "Wind Electrical System", Oxford University Press, first edition, 2005. 5. https://onlinecourses-archive.nptel.ac.in/.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. S. Biswas, Scientist-F, IGCAR, Kalpakkam	1. Dr. K. Vijayakumar, IIITDM, Kanchipuram	1. Dr. S. Padmini, SRMIST
2. Dr. T. Prakash, TANTRANSCO	2. Dr. B. Chitti Babu, IIITDM, Kanchipuram	2. Dr. R. Sridhar, SRMIST

Course Code	21EEE331T	Course Name	ENVIRONMENTAL SECURITY AND SUSTAINING PEACE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	obtain the essential of safe and healthy environment for bringing growth and prosperity to society
CLR-2:	familiarize the concept of natural resources conflict and the environment impact
CLR-3:	enrich the knowledge of armed conflict harms the environment
CLR-4:	discover how natural resources and the environment support peace building
CLR-5:	assess and address the relationship between natural resources conflict

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	explain the basics of environmental security and sustaining peace	2	-	-	-	-	1	3	2	-	-	-	3	-	-	2
CO-2:	describes the concept of natural resources conflict and the environment impact	2	-	-	-	-	1	3	2	-	-	-	3	-	-	2
CO-3:	explain how the armed conflict harms natural resources and the environment	2	-	-	-	-	1	3	2	-	-	-	3	-	-	2
CO-4:	examine the natural resources and the environment support peace building	2	-	-	-	-	1	3	2	-	-	-	3	-	-	2
CO-5:	interpret the relationship between natural resources conflict	2	-	-	-	-	1	-	2	3	3	-	3	-	-	2

Unit-1 - Environmental Security and Sustaining Peace — ***9 Hour***

Introduction: Environmental Security and Sustaining Peace, Evolution of Environment, Peace, and Conflict Linkages, Conceptual Framework for Environmental Peace building, sustaining peace through better resource governance, Environmental peace building in South Asia: Establishing consensus on hydroelectric projects.

Unit-2 - Natural Resources and Conflict Causes — ***9 Hour***

Role Drivers of Violent Conflict Emergence, Climate Stress, Conflict, and Peace building, Governance and Resilience, Transparency and Access to Information, Conflict Sensitivity, Mediating Natural Resource Conflicts, Role of Electrical Engineers in Environmental Security for Sustaining Peace.

Unit-3 - Natural Resources and the Environment during Armed Conflict — ***9 Hour***

The Importance of Natural Resources during Conflict, Environmental Impacts of Armed Conflict, Breakdown of Environmental Governance and Social Relationships, Conflict Resources and Pillage, National Tools for Addressing Conflict Resources, International Law Protecting the Environment during Armed Conflict, Implementing International Law during Armed Conflict, UN Security Council Tools for Addressing Resource Conflicts, Natural Resources in Peace Agreements.

Unit-4 - Post-Conflict Environmental Peacebuilding — ***9 Hour***

Environment and Natural Resources in Post-Conflict Assessments, Renewable and Nonrenewable Resources for Recovery, Natural Resources in Security and Stabilization, Restoring Livelihoods and Building Resilience, Resources as Entry Points for Dialogue and Cooperation, Rebuilding Environmental Governance, Empowering Women in Natural Resource Management and Peace building, Spatial Planning and Recovery, Mitigating Environmental Impacts of Reconstruction, Coordination in Peace building.

Unit-5 - Case Studies on Environmental Peacebuilding — ***9 Hour***

Environmental Peace building in South Asia, Extractives and Peace building in Aynak, Afghanistan, Diamonds and Conflict in Sierra Leone, Climate Change Dimensions of the Arab Spring, Land as a Conflict Driver in Sierra Leone, Blood Chocolate - Cacao and Conflict in Cote d'Ivoire, Diamonds, Timber and Conflict in Liberia, Cooperation around Shared Water in the Jordan River, Environmental Peace building through Water Management in Wadi El Ku, Sudan, grassroots environmental peace building in south Asia.

Learning Resources	1. *Carl Bruch, David Jensen, Richard A Matthew, Erika Weinthal, "Environmental Security and Sustaining Peace", 2019.* 2. *T. Ide, C. Bruch, A. Carius, K. Conca, G. D. Dabelko, R. Matthew and E. Weinthal, "The past and future of environmental peacebuilding", International Affairs, 2021.* 3. *Mirza Sadaqat Huda, "An ecological response to ethno-nationalistic populism: grassroots environmental peacebuilding in south Asia", International Affairs, 2021.*	4. *Anaïs Dresse, Itay Fischhendler, Jonas Ostergaard Nielsen and Dimitrios Zikos, "Environmental peace building: Towards a theoretical framework", 2019.* 5. *https://www.edx.org/course/environmental-security-and-sustaining-peace*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	*20%*	-	*30%*	-
Level 2	*Understand*	*30%*	-	*20%*	-	*30%*	-
Level 3	*Apply*	-	-	-	-	-	-
Level 4	*Analyze*	*40%*	-	*60%*	-	*40%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100%*		*100%*		*100%*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. M. Basheer Khan, Reef Real Estate Investment Co. LLC, Dubai, UAE*	1. *Dr. A. Venkatesan, NIT Puduchery*	1. *Dr. T. M. Thamizh Thentral, SRMIST*
2. *Ms. S. Alamelumangai, Naval Armament Depot, Mumbai*	2. *Dr. V. Sankaranarayanan, NIT Trichy*	2. *Dr. R. Ramya, SRMIST*

Course Code	21EEE332T	Course Name	SUSTAINABLE CHALLENGES IN CITIES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*recognize the concept of urban governance*
CLR-2:	*realize the options for the planning and execution of city functions*
CLR-3:	*impart knowledge on mitigation and development of secondary cities*
CLR-4:	*gain the knowledge of improving human development in cities*
CLR-5:	*explore the global processing through financial and structural development*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*outline the theme of urban culture, social transformations and natural resources*	*3*	-	-	-	-	*2*	*2*	-	-	-	-	-	-	-	*2*
CO-2:	*familiarize the concept for the city development with safety measures*	*3*	-	-	-	-	*2*	*2*	-	-	-	-	-	-	-	*2*
CO-3:	*illustrate the reduction of urban vulnerable towards sustainability*	*2*	-	-	-	-	*2*	*2*	-	-	-	-	-	-	-	*2*
CO-4:	*facilitate the impact of gender equality through higher education*	*3*	-	-	-	-	*2*	*2*	-	-	-	-	-	-	-	*2*
CO-5:	*acquire knowledge on the universal urban services and infrastructure development*	*3*	-	-	-	-	*2*	*2*	-	-	-	-	-	-	-	*2*

Unit-1 - The Urban Opportunity	***9 Hour***
The urban opportunity-Cities: cultural and social transformation-Challenge of urban politics, planning and governance-Urban research methods-Urban theory and history- Understanding urban systems-Municipal, regional and national governance-Urban utilities- Air, water, food and natural resources.	
Unit-2 - Development Options for City Function	***9 Hour***
Urban public finance and taxation-Law, order and conflict-Land management and planning-Lessons from London and Mumbai-urban poverty-Measuring urban poverty-Poverty reduction in cities- Affordable and adequate housing- Climate impacts, adaptation, and mitigation- Making cities more sustainable- Implementing urban sustainability.	
Unit-3 - Reduction of Urban Poverty with the Improvement of Safety Factors	***9 Hour***
Need for housing -Safety and violence-Urban vulnerabilities- City production and consumption-Women in the informal economy-Migration, mobility and the urban-rural continuum- Wealth and inequality-Case study on SEWA, India- Migration and the refugee crisis- Opportunities of secondary cities- New institutions and governance.	
Unit-4 - Improving Human Development in Cities	***9 Hour***
Addressing the challenges of urban public health-Solutions for improving urban health-Education and skills-Higher education in cities-Gender in the city-Human rights and justice-Law and equality-Apartheid in South African cities-Sustainable environmental services and infrastructure-Sustainable transport planning-Sustainable urban energy systems.	
Unit-5 - Universal Urban Services and Infrastructure	***9 Hour***
City risk exposure-Building urban resilience-Environmental planning and the policy of change-Sustainable environmental practices: Durban-Urban disaster risk management-SDGs and other global processes-Financing sustainable development-Measuring and monitoring the SDGs-Local leadership: a case study of Melbourne-International climate action: A case of Chinese cities.	

Learning Resources	1. *Introduction to Sustainable Development by Martin J. Ossewaarde, SAGE Publications Pvt. Ltd; first edition, 2018.* 2. *Managing Sustainable Development Concepts Issues and Challenges by Mishra, P K & J K Verma, Associated Publishing Company, first edition, 2019.*	3. *https://www.unsdglearn.org/courses/* 4. *https://www.edx.org/school/sdgacademyx* 5. *https://www.coursera.org/learn/global-sustainable-development* 6. *https://www.classcentral.com/institution/sdg-academy* 7. *https://www.humanrightscareers.com/un-sustainable-development-goals-courses/*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*35%*	-	*30%*	-	*40%*	-
Level 2	*Understand*	*35%*	-	*35%*	-	*30%*	-
Level 3	*Apply*	*20%*	-	*25%*	-	*20%*	-
Level 4	*Analyze*	*10%*	-	*10%*	-	*10%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Kannan, Seshasayee Paper and Boards Limited (SPB)*	1. *Dr. A. Venkatasen, NIT Puducherry*	1. *Dr. D. Karthikeyan, SRMIST*
2. *Mr. Kumaresan, NTPC Chennai*	2. *Dr. A. Balaji, SSN College of Engineering, Chennai*	2. *Dr. K. Selvakumar, SRMIST*

Course Code	21EEE333T	Course Name	CLIMATE CHANGE AND SOCIO-ECONOMIC SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the effect of greenhouse gas emission in the environment*
CLR-2:	*identify the limits of greenhouse gas emission of various sectors*
CLR-3:	*calculate the cost of energy with inclusion of emission factors*
CLR-4:	*outline the life cycle of carbon*
CLR-5:	*indicate the effect of greenhouse gases in environment*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the structure and model of atmosphere and carbon cycle*	*2*	-	-	-	-	*3*	*3*	-	-	-	-	*1*	-	-	*2*
CO-2:	*acquire knowledge on climate policies at a global level*	*2*	-	-	-	-	*3*	*3*	*3*	-	-	-	*2*	-	-	*2*
CO-3:	*acquire knowledge on pricing mechanism of various emission trading system*	*3*	-	-	-	-	*3*	*2*	*2*	-	-	-	*2*	-	-	*1*
CO-4:	*learn the concept of climate changing models*	*3*	-	-	-	-	*2*	*2*	-	-	-	-	-	-	-	*2*
CO-5:	*infer the mitigation of climate change*	*3*	-	-	-	-	*3*	*3*	-	-	-	-	*1*	-	-	*1*

Unit-1 - Introduction	***9 Hour***
Introduction to climate change, Energy Balance and Climate, Vertical Structure of the Atmosphere, The greenhouse effect, Blackbody Radiation, The layer Model. Greenhouse gases, Weather and climate, carbon on earth, Fossil fuels and energy, perturbed carbon cycle.	
Unit-2 - Global Energy and Climate Policy	***9 Hour***
climate policy instruments and framework conditions, Federal Climate Policy: Reducing Emissions, Economy-Wide Policies, The Power Sector, The Transportation Sector, The Industrial Sector, The Buildings Sector, Land Use, Forestry, and Agriculture, The Oil and Gas Industry, Tools in the Climate Policy Toolkit, Carbon pricing, Performance standards, Technology Deployment Subsidies, Carbon Pricing Policies.	
Unit-3 - The Economics of Climate Change	***9 Hour***
Cost of energy, Energy policy design, carbon trading, Kyoto protocol, Emission trading systems, Cap and trade, Baseline and credit, carbon tax, carbon offset mechanism, internal carbon pricing, Renewable energy certificates, White certificates, Green financial instruments, Green bonds, Green bonds principles, Green loans, Green loans principles, Green sukuk, Catastrophe bonds (cat bonds), Climate bonds, Challenges and path ahead to unlock the green potential.	
Unit-4 - Climate Change Modelling	***9 Hour***
The Carbon Cycle, The Earth's Energy Balance, Black Body Radiation, A Simple Climate Model - The 1-Layer Model, The n-Layer Model, The Atmospheric Lifetime of CO2, Energy Efficiency, Carbon Capture and Sequestration, Forestation and Deforestation.	
Unit-5 - Climate Change Mitigation	***9 Hour***
Introduction to climate mitigation, Complexity of climate change and development, Climate change - a super wicked problem, theory of change, MAPS 101: the MAPS approach, Effectiveness in Achieving Emissions Reductions.	

Learning Resources	1. *Archer, David, "Global Warming: Understanding the Forecast", Wiley, 2011. ISBN: 9780470943410.* 2. *Climate Change 2007—The Physical Science Basis: Working Group I Contribution to the Fourth Assessment Report of the IPCC, Cambridge University Press, 2007. ISBN: 9780521880091.*	3. *Global Warming I: The Science and Modeling of Climate Change, https://in.coursera.org/learn/global-warming.* 4. *Richard G. Newell, "Federal Climate Policy 101: Reducing Emissions", Explainer publications, 2021.* 5. *Sevil Acar, Erinc Yeldan, "Handbook of Green Economics", Elsevier publications, first edition, 2019.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*40%*	*-*	*20%*	*-*	*30%*	*-*
Level 2	*Understand*	*40%*	*-*	*20%*	*-*	*30%*	*-*
Level 3	*Apply*	*10%*	*-*	*30%*	*-*	*20%*	*-*
Level 4	*Analyze*	*10%*	*-*	*30%*	*-*	*20%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. Bhaskarsahu, Schneider Electric Ltd.*	1. *Dr. K. S. Swarup, IIT Madras*	1. *Dr. K. Selvakumar, SRMIST*
2. *Mr. R. Paneerselvam, Retd S.E/south/TANGEDCO – GM, IHPC*	2. *Dr. M. Senthil Kumar, NIT Patna*	2. *Dr. R. Ramya, SRMIST*

Course Code	21EEE401T	Course Name	SMART GRID OPERATION AND PLANNING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*acquire knowledge on the development of smart grid environment*
CLR-2:	*identify the issues and challenges of renewable energy integration in smart grid*
CLR-3:	*understand the operation and control of smart grid environment*
CLR-4:	*outline the micro grid system and its economics*
CLR-5:	*acquire knowledge on demand side management in smart grid*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the concept and developments of smart grid*	*3*	-	-	-	-	-	-	*2*	-	-	-	*1*	-	-	*2*
CO-2:	*interpret the RES integration and planning strategies of smart grids*	*3*	-	-	-	-	-	*2*	*2*	-	-	-	*2*	-	-	*3*
CO-3:	*acquire knowledge on smart grid components and process*	*3*	-	-	-	-	-	*1*	-	-	-	-	*2*	-	-	*3*
CO-4:	*learn the concept of micro grid architecture and its smart utilization*	*3*	-	-	-	-	-	*2*	-	-	-	-	-	-	-	*2*
CO-5:	*understand the operation and control concepts of smart grid distribution*	*3*	-	-	-	-	-	*1*	-	-	-	-	*1*	-	-	*2*

Unit-1 - Smart Grid and Communication Infrastructures	***9 Hour***
Transition to Smart Grid-Structure of modern power systems-Definitions of Smart Grid, Smart Grid Components, Concept of Resilient and Self-Healing Grid, IEEE standards of Smart Grid, National and International Initiatives in Smart Grid-Smart grid enabling technologies- Smart grid challenges and barriers-Wide area monitoring-SCADA-PMU-Smart meters and Advanced metering infrastructure-Smart grid communications-Architecture of smart grid communications-Smart grid layers.	
Unit-2 - Renewable Energy Integration in Smart Grid	***9 Hour***
Renewable energy integration in smart grid- Technical challenges in integration of Renewables-Regulations and standards of renewable integration-Grid energy storage technologies- Energy storage operation strategies-Control strategies of renewable energy systems-Power electronic interfaces in RE integration-Centralized control scheme- Decentralized control Scheme-Case studies.	
Unit-3 - Smart Grid Technologies	***9 Hour***
Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Protection and control, Distribution systems: DMS, Volt/VAr control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers	
Unit-4 - Microgrid and Energy Management	***9 Hour***
Microgrid concept- Virtual power plants-Microgrid Architecture-Components and Challenges-Microgrid protection in smart grid-DC and AC microgrid-Market Models for Microgrids - Operation of multi microgrids-Electric vehicle technologies-Plug in Hybrid vehicle topology-Vehicle to Grid and Grid to Vehicle issues-Case studies.	
Unit-5 - Operation and Control of Smart Grids	***9 Hour***
Operational aspects of smart grid system, active and reactive power response, control concepts in smart distribution system, Demand side management of smart grid, Demand response analysis of smart grid- Data management in smart grid-Protection and control in substations-Smart grid operation and planning.	

Learning Resources	1. *Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press, River Publishers; first edition, 2009.* 2. *Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, 'Smart Grid: Technology and Applications', Wiley, first edition, 2012.* 3. *J. Momoh, "Smart Grid: Fundamentals of Design and Analysis," Wiley-IEEE Press, first edition, 2012.*	4. *S. K. Salman, "Introduction to the Smart Grid: Concepts, Technologies and Evolution," IET Energy Engineering Series, first edition, 2017.* 5. *J. Ekanayake, N. Jenkins, K. Liyanage, J. Wu, A. Yokoyama, "Smart Grid: Technology and Applications," John Wiley and Sons, first edition, 2015.* 6. *Radian Belu, "Energy Storage, Grid Integration, Energy Economics, and the Environment", CRC Press, first edition, 2019.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Sudharsan, L&T*	1. *Dr. Subhransu Sekhar Dash, Government College of Engineering, Keonjhar*	1. *Dr. K. Selvakumar, SRMIST*
2. *Dr. K. Karthikeyan, ABB India Ltd.*	2. *Dr. R. Ramesh, College of Engineering, Anna University, Chennai*	2. *Dr. J. Preetha Roselyn, SRMIST*

Course Code	21EEE402T	Course Name	AI IN SMART BUILDINGS AND ELECTRIC VEHICLES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*acquire the knowledge of smart building configuration and its control*
CLR-2:	*understand the concept of different ventilation system adopted for smart buildings*
CLR-3:	*familiarize the importance of artificial intelligence in smart building*
CLR-4:	*elucidate the application of artificial intelligence in electric and autonomous vehicles*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*comprehend the anatomy of intelligent building and its controls*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*summarize the concept of heating, cooling and ventilation concepts of smart building*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*incorporate artificial intelligence in construction of smart building and its appliance controls*	*3*	*2*	-	-	*2*	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*apply the knowledge of artificial intelligence to electric and autonomous vehicles*	*3*	*2*	-	-	*2*	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Intelligent Building — ***9 Hour***

Features and benefits of intelligent buildings, Anatomy of intelligent buildings and environmental aspect. Building automation systems and controls: system configuration, system modules, distributed systems, communication protocol and on-line measurements. Fire protection, security and energy management. Control objectives - Sensors, controllers and actuators; Control system schematics system design; Microprocessor based controllers & digital controls.

Unit-2 - Control and Optimization of Air Conditioning and Chiller Unit — ***9 Hour***

Introduction to heating, cooling and ventilation system; Control loops for air conditioning process, control of CAV and VAV systems, outdoor air ventilation control. Overview of optimal control methods for HVAC systems- Pneumatic control in HVAC, Direct Digital control in HVAC, Rule based control in HVAC, Model predictive control in HVAC, Cloud based adaptive Model predictive control, Intelligent controls in HVAC - Chillers and central chilling system configurations, optimal control of heat rejection system and optimal set point reset of chilled water supply temperature.

Unit-3 - AI in Smart Building — ***9 Hour***

Building parameters of AI in smart building; Intelligent appliances control through AI - AI for Actuation of Heating and cooling systems -Ventilation systems- indoor lighting systems (AI based illuminance control). Building Energy Management System (BMS and DRPs); Preventive maintenance and Fault detection. Intelligent renewable energy and load forecasting in smart buildings; AI for Energy Efficiency and Energy Accessibility; AI based control for emergency navigation systems, human interaction and parking assistance; Data privacy and security. Machine learning for human activity recognition and detection and object detection; Application development for monitoring and energy consumption.

Unit-4 - AI for Electric Vehicles (EV) — ***9 Hour***

AI in automative Industry, Major Players in AI automobile Industry, Introduction to EV technologies, AI in EV industry. Intelligent Battery management system and AI for motor drive control in EV. Optimization techniques used in active magnetic Bearing system for EV. AI in electric vehicle for wireless power transfer systems, AI technology for Electric Vehicle scheduling of charging and discharging, AI based optimal planning of Electric vehicle infrastructure.

Unit-5 - AI for Autonomous Vehicles — ***9 Hour***

Introduction to autonomous driving technology, AI in autonomous vehicle- Driver monitoring and driver replacement, vision, sensor fusion, vehicle power trains. Safety and security of autonomous vehicles and route planning.

Learning Resources	1. *Clements-Croome, Derek, "Intelligent Buildings: An introduction", Routledge, first edition, 2014.* 2. *Shengwei Wang, "Intelligent Buildings and Building Automation", Spon Press, first edition, 2010.* 3. *P. Manolescue, "Integrating Security into Intelligent Buildings", Cheltenharn, 2003.* 4. *Chitra A, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen, S.Himavathi, "Artificial Intelligent Techniques for Electric and Hybrid Electric Vehicles", Wiley, first edition, 2020.*	5. *Kevin P. Murphy, "Machine Learning: A probabilistic Perspective", MIT Press, 2012.* 6. *James Larminie and John Lowry, "Electric Vehicle Technology Explained", Wiley, second edition, 2012.* 7. *Romil Rawat, A Mary Sowjanya, Syed Imran Patel, Varshali Jaiswal, Imran Khan and Allam Balaram, "Vehicles using Machine Intelligence", Wiley-Scrivener publication, first edition, 2022.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Bhaskar Sahu, Schneider*	1. *Dr. K.S. Swarup, IIT Madras*	1. *Dr. D. Suchitra, SRMIST*
2. *Mr. Vijayarajeswaran, Vi micro–Pvt Ltd.*	2. *Dr. D. Devaraj, KARE*	2. *Dr. R. Annie Uthra, SRMIST*

Course Code	21EEE403T	Course Name	HIGH VOLTAGE ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*outline the concepts of over voltages and insulation co-ordination on power system*
CLR-2:	*discuss the solid, liquid and gaseous dielectrics with its relevance to application of high voltages*
CLR-3:	*understand the concept of generation of high voltages*
CLR-4:	*familiarize the concept on the measurement of high voltages and currents*
CLR-5:	*describe the testing of high voltage equipments and its application*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*gain knowledge on overvoltage protection and the importance on insulation co-ordination levels*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*understand the basics of dielectrics and its breakdown process on high voltage application*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*acquire knowledge of high voltage generation*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*gain knowledge on measurement of high voltage generation*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*demonstrate the testing procedures on high voltage equipment and its application*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Overvoltages in Power Systems ***9 Hour***

Causes of overvoltages –Travelling waves on Transmission lines- Overvoltage due to switching surges- Power Frequency Overvoltages in Power Systems-- Protection against Lightning overvoltages and switching surges of short duration-Ground wires- Protection of transmission lines against over voltages-Ground rods and counter-poise wires- Protective devices-Rod gap, Expulsion gap- Protector tubes, Surge arrester-Principles of Insulation Coordination-Ideal requirements of a protective device- Surge diverters-Equipment insulation level and insulation co-ordination of substation-Insulation level at substation with protective zone-Insulation Coordination in EHV and UHV systems.

Unit-2 - Conduction and Breakdown in Gases ***9 Hour***

Gaseous breakdown in uniform and non-uniform fields-Conduction and breakdown in gases-Ionization process-Townsend's current growth equation in the presence of secondary processes -Breakdown in electronegative gases-Time lags for breakdown-Streamer Breakdown mechanism in gases-Paschen's law-Derivation-Practical Considerations in using gases for insulation purposes-vacuum breakdown-Liquid as insulators-Electrical properties-Conduction and breakdown in pure and commercial liquids-Breakdown mechanisms in solid dielectrics-Intrinsic and Electromechanical breakdown, Thermal breakdown, solid breakdown used in practice ,Mechanism of breakdown in composite dielectrics.

Unit-3 - Generation of High Voltages ***9 Hour***

Generation of high DC voltages – Half-wave and full-wave rectifier circuits-Voltage doubler circuits-voltage multiplier circuits -Van de Graff generator-Generation of high alternating voltages-Cascaded transformer-Resonant transformer-Series connection-Resonant transformer-Parallel connection-Generation of high frequency alternating voltages- Advantages-Tesla coil equivalent circuit-Generation of impulse voltages-Standard impulse waveshapes-Multistage impulse generator-Marx circuit-Generation of impulse current-Definition- Circuits for producing impulse current waves-Generation of rectangular current pulses-Circuits for producing switching surge voltages -Tripping and control of impulse generators- Trigatron gap.

Unit-4 - Measurements of High Voltages and Currents	***9 Hour***
Measurement of High D.C Voltages-Measurement of high A.C and impulse voltages- Electrostatic voltmeter, Peak reading ac voltmeter-Series capacitor, peak voltmeter-Digital peak voltmeter-Measurement of high dc, ac and impulse voltages -Sphere gap measurement- Resistance and Capacitance Potential dividers for impulse voltage measurements-Measurement of high DC, AC and impulse measurements-High DC currents-DC current transformer-Hall generators-Measurement of high frequency and impulse currents- Rogowski coils, Magnetic links, Faraday Generator-Cathode Ray Oscillographs for Impulse voltage and current measurements.	
Unit-5 - Testing of High Voltages Electrical Apparatus	***9 Hour***
Technical terms-Definition for high voltage testing (IS2259)-Testing procedures on insulators-Testing procedures on bushings (IS2099)-Testing procedures on isolators-Testing procedures on Cables-Testing procedures on Circuit breakers (BS 116:1952)-Testing procedures on transformers-Testing procedures of surge diverters-Radio Interference Measurements – Measurement of Radio Interference voltage-Non-destructive testing of materials and measurement of direct current resistivity-Measurement of dielectric constant and loss factor. Partial discharge measurements-Application of high voltage engineering in food processing and bio-medical industry.	

Learning Resources	1. *Naidu.M.S, Kamaraju, "High Voltage Engineering", Tata McGraw Hill, sixth edition, 2020.* 2. *Wadhwa.C.L, "High Voltage Engineering", new age international publishers Ltd, third edition, 2012.* 3. *Ravindra Arora, Wolfgang Mosh, "High Voltage and Electrical Insulation Engineering", Wiley-IEEE Press, second edition, 2022.*	4. *G.V. Barbosa Canovas, "Pulsed electric fields in food processing: Fundamental Aspects and applications", CRC Publisher Edition, 2020.* 5. *H. L. M. Lelieveld, Notermans.S, "Food preservation by pulsed electric Fields: From research to application", Woodhead Publishing Ltd., first edition, 2007.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. S. Paramasivam, Danfoss Industries Pvt. Ltd.*	1. *Dr. R. Sarathi, IITM, Chennai*	1. *Dr. S. Padmini, SRMIST*
2. *Dr. T. Prakash, TNEB*	2. *Dr. P. Valsalal, Anna University*	2. *Mr. B. Vinoth Kumar, SRMIST*

Course Code	21EEE404T	Course Name	DATA ANALYTICS AND CYBERSECURITY FOR ENERGY SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the statistical learning approaches for power system monitoring and operations*
CLR-2:	*understand the forecasting and uncertainties of renewable energy generation*
CLR-3:	*enrich the knowledge on data driven anomaly detection for outages and grid robustness*
CLR-4:	*understand the data injection attacks in centralized and decentralized way in power systems*
CLR-5:	*enrich on data quality, privacy and data recovery in smart grid*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*enumerate the understanding of data learning algorithms in power system*	*2*	-	-	-	-	-	-	*2*	-	-	-	-	-	*2*	-
CO-2:	*summarize the different forecasting and uncertainties in renewable energy*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*demonstrate the anomaly detection algorithms for power system failures*	*3*	-	-	-	*2*	-	-	-	-	-	-	*2*	-	*2*	-
CO-4:	*formulate cybersecurity attacks in smart grid*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-	*2*	-
CO-5:	*develop algorithms for data correction and data recovery in smart grid*	*3*	-	-	-	*2*	-	-	-	-	-	-	*2*	-	*2*	-

Unit-1 - Statistical Learning Approaches in Power Systems ***9 Hour***

Importance of data analytics in energy systems-Analytical models in energy systems-Data preparation and exploration-Data cleaning and reduction-Energy data analytics using machine learning approach-Regression and classification-based algorithms-Clustering based model-Topology detection in smart meter data-data mining applications in power systems-fault detection and diagnosis using data analytics- ISO/IEC standards for cybersecurity.

Unit-2 - Energy Forecasting and Uncertainties in Renewables ***9 Hour***

Short term energy forecasting in wind and solar energy systems- Effect of weather forecasts in conditional forecasting-Probabilistic using Monte Carlo Simulation-Wind power uncertainty characteristics- PV power uncertainty characteristics-Spatial temporal correlations of wind and solar power output-Indices for evaluating forecast accuracy-Managing renewable energy uncertainty in electricity market.

Unit-3 - Data Driven Anomaly Detection in Energy Systems ***9 Hour***

Pre outage and post outage model in smart grid-Anomaly detection using synchrophasor data-PMU data anomalies-ML based anomaly detection-classification and localization-Data drift in smart grid measurements-Data preprocessing model-Anomaly detection using clustering methods-Line outage detection-Agile detection of power system anomalies.

Unit-4 - Cyber Attacks in Smart Grid ***9 Hour***

Bayesian state estimation-Deterministic state model-Attack detection -Minimum probability of detection attacks-Random attack model- Attack construction with estimated state variables-Smart meter and PMU data privacy concerns-Attack methods in smart grid.

Unit-5 - Data Privacy and Recovery ***9 Hour***

Privacy preserving techniques- Security control in smart grid-Situational awareness-Data sharing prevention techniques-Smart meter data privacy techniques- Low dimensionality of PMU data-PMU data recovery-Bad data correction-Data recovery under multiple disturbances-Location of corrupted devices

Learning Resources	1. *Ali Tajar, Samir M.Perlaza, H.Vincent Poor, "Advanced data analytics for power systems", Cambridge University Press, 2021.* 2. *Ning Zhang, Chongqing Kang, Ershan Du, Yi Wang, "Analytics and Optimization for Renewable energy integration", CRC Press, first edition, 2019.*	3. *Denis Sidorov, "Machine learning for energy systems", MDPI, 2020.* 4. *Zita Vale, Tiago Pinto," Intelligent data mining and analysis in power and energy systems", IEEE Press, John Wiley and Sons, first edition, 2023.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	*30%*	-	*30%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*40%*	-	*40%*	-	*40%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Deb Singhdeo, Mathworks*	1. *Ms. Jyothi Janardhan, NIOT*	1. *Dr. J. Preetha Roselyn, SRMIST*
2. *Mr. Muralikrishnan, Optithought*	2. *Dr. Prabha Sundar, University of Texas*	2. *Dr. U. Sowmmiya, SRMIST*

Course Code	21EEE405L	Course Name	SOFTWARE TOOLS FOR POWER ELECTRONICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							1	0	4	3

Pre-requisite Courses	21EEC301J	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	impart knowledge on the power electronic devices and its fabrication through PSIM and PCB simulation software
CLR-2:	perform simulation on the electromagnetic design of electrical components through ANSYS, ALTAIR flux, and magnet software
CLR-3:	execute simulation on various hardware-in-loop platforms

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	design and develop power electronic circuitry through PSIM and PCB simulation software	3	-	3	-	3	-	-	-	-	-	-	-	2	-	-
CO-2:	analyze the behavior and performance of electrical apparatus through ANSYS, ALTAIR flux and magnet software	3	-	3	-	3	-	-	-	-	-	-	-	2	-	-
CO-3:	apply the knowledge on power electronic interfaces through HIL implementations	3	-	3	-	3	-	-	-	-	-	-	-	2	-	-

Unit-1 - PSIM Simulation	**15 Hour**
Introduction to PSIM -device panel -simulation setting and tool bars, Simulation of switching characteristics of IGBT and MOSFETS, modelling of power switching devices from manufacturer datasheet embedded C-generation of PWM and complementary PWM. Design and Simulation of snubbers, calculation of switching and conduction losses in power switching devices, simulation of abc-dq and dq-abc transform, simulation of harmonics and calculation THD, design and simulation of power filters.	
Unit-2 - PCB Simulation and Fabrication	**15 Hour**
Layout and tools of PCB fabrication software, schematics PCB layout, Footprint Creation of Electronics Components - Footprint Assignment - Net list Generation – BOM Generation Switching to Printed Circuit Board Design (PCB Design) - Board Shapes and Board Restrictions - Footprint Placements on PCB - PCB Layer Stack Up Setup and Calculations - Routing of Signal and Power Tracks - Constraint Manager Settings - Fabrication Outputs-Gerber Data for Fabrication; Footprint Position data for Assembly, development of various power converters as PCB layouts.	
Unit-3 - ANSYS and ALTAIR Flux	**15 Hour**
Introduction to ANSYS Maxwell software -application in Electrical Engineering - RMxprt Design -Design Parameter and Material Properties, Coil Creation, analysis-Magnetostatic, Eddy current, Transient, Electrostatic, Export RMxprt Model for Maxwell 2D and 3D Analysis -Finite Element Analysis of electrical machines - simplorer maxwell co -design. Altair flux: Multiphysics capabilities – magneto static, steady-state, and transient conditions- electrical and thermal properties – optimize machine/transformer performance, high frequency transformers, insulator, power bars, and circuit breakers.	
Unit-4 - Magnet Simulation	**15 Hour**
Introduction to MagNet – model building – modeling flowchart – geometric modeling – drawing edges – creating surface – creating components – selecting edges surfaces and components – positioning the construction slice – material, boundary condition and finite element mesh – solving the model. Design and simulation of special electric motors with customized slots using MagNet software.	
Unit-5 - Hardware in the Loop (HIL)	**15 Hour**
Introduction to dSPACE-software interface- generation and extraction of PWM for power converters- Opal-RT real time simulator for inverter fed motor drives- Solar PV array simulator – configuring- PV array- partial shading- interfacing with programmable source. Wavect simulator- generation of bin- grid interactive renewable sources. Power tracking algorithms for photovoltaic using dSPACE, inverter applications using Opal-RT, PV array configuration using solar emulator, wavect with grid interfaces.	

Learning Resources	1. *https://powersimtech.com/wp-content/uploads/2021/01/PSIM-User-Manual.pdf* 2. *Mark I. Montrose, "Printed Circuit Board Design Techniques for EMC Compliance: A Handbook for Designers", Wiley-IEEE Press, second edition, 2000.*	3. *Gopal. K. Dubey, "Fundamentals of Electrical Drives", Narosa Publishing House, twenty eighth edition, 2011.* 4. *B.K. Bose," Modern Power Electronics and AC Drives", Pearson Publications, first edition, 2008*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		CLA-1 Average of first cycle experiments (30%)		*CLA-2 Average of second cycle experiments (30%)*		*Practical Examination (40% weightage)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 2	*Understand*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 3	*Apply*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 4	*Analyze*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 5	*Evaluate*	-	-	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*		-	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. R. Parthipan, Igarashi Motors India Limited*	1. *Dr. A. Venkadesan, NIT Puducherry, Karaikal*	1. *Dr. R. Sridhar, SRMIST*
2. *Mr. S.S. Biswas, Dept. of Atomic Energy, Kalpakkam*	2. *Dr. R. Ramesh, CEG, Chennai*	2. *Dr. J. Divya Navamani, SRMIST*

Course Code	21EEE406T	Course Name	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*impart knowledge on the need of power electronics for renewable power generation*
CLR-2:	*illustrate the working and design of photovoltaic and wind energy conversion system with the aid of power converters*
CLR-3:	*gain knowledge on design of power converters for hybrid renewable energy system*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*comprehend the significance of power converters in renewable power generation schemes*	2	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*apply suitable power electronic converters for photovoltaic and wind energy conversion system*	2	2	2	-	2	-	-	-	-	-	-	-	2	-	-
CO-3:	*analyze the design of power converters and energy storage in various configurations of hybrid renewable energy system*	2	2	2	-	2	-	-	-	-	-	-	-	2	-	-

Unit-1 - Introduction to Role of Power Converters in Renewable Sources ***9 Hour***

Wind, solar, fuel cell availability and power extraction, unique features of decentralized Systems, Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment, Grid codes in India and other countries, Need of power electronics for power generation from renewable energies, Power electronic converters and control for Micro grids and Smart grids.

Unit-2 - Solar PV Systems ***9 Hour***

Solar PV characteristics, PV modules and arrays; effect of shading, use of bypass and blocking diodes, Design and simulation of PV system-load calculation, array sizing, selection of converter/inverter, battery sizing, Power electronic converters used for solar PV, transformer less inverters, centralized grid-connected three-phase inverters for large PV installations, Control techniques, Grid requirement for PV, MPPT, Grid connected and Islanding mode, Grid synchronization, PLLs

Unit-3 - Wind Energy Conversion ***9 Hour***

Generators in Wind Turbine Systems, Power electronic converters for wind turbine system, AC/DC/AC converters for power electronic interface, Wind energy conversion system configuration- variable speed system with reduced and full-capacity power converters, Design and simulation of electrical components in Wind energy conversion system, Wind interconnection requirements, controllability of wind turbine connected through L and LC filter to the grid.

Unit-4 - Batteries and Fuel Cell ***9 Hour***

Batteries, classical batteries, Battery Parameters-Battery life & safety impacts -Battery Modeling, Benefits of Li-Ion battery, super capacitor, Renewable energy storage-Battery sizing and stand-alone applications, stationary (Power Grid application), Fuel cell and types of fuel cell, Modeling of Fuel Cell, Energy generation technology in fuel cell, Fuel Cell usage for domestic power systems, Design and simulation of fuel cell system with various power generating capacity.

Unit-5 - Hybrid Energy System ***9 Hour***

Need for Hybrid Systems, Features of Hybrid Systems, Range and types, of Hybrid systems (Wind-Diesel, PV-Diesel and Wind-PV), Energy Management in Hybrid Systems, software tools for Hybrid Energy Systems, Optimization and power Quality issues in hybrid energy systems, Multiport power converter topologies - Single-Input Multi-Output (SIMO), Multi-Input Single-Output (MISO) and Multi-Input Multi-Output (MIMO).

Learning Resources	1. *Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Pearson, 10th Impression, fourth edition, 2021.* 2. *Chetan Singh Solanki, "Solar Photovoltaics", PHI Learning Private Limited, third edition, 2018.* 3. *Muhammad Rashid, "Power Electronics Handbook, Devices, Circuits and Applications", second edition, 2006.*	4. *Fang Lin Luo, Hong Ye, "Advanced DC/DC Converters", CRC press, second edition, 2016.* 5. *Sudipta Chakraborty, Marcelo G. Simões, William E. Kramer, "Power Electronics for Renewable and Distributed Energy Systems", Springer, 2013.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Jason Manoraj, L&T Technology Services Limited*	1. *Dr. R. Ramesh, CEG, Chennai*	1. *Dr. J. Divya Navamani, SRMIST*
2. *Dr. S. Sambath, TANGEDCO*	2. *Dr. A. Venkadesan, NIT, Puducherry*	2. *Dr. R. Sridhar, SRMIST*

Course Code	21EEE407T	Course Name	ADVANCED POWER SEMICONDUCTOR DEVICES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*explain the concept of power switching devices*
CLR-2:	*describe the theme of various current controlled devices*
CLR-3:	*illustrate the concept of voltage controlled devices*
CLR-4:	*gain the knowledge of firing and protecting circuits for power electronic converters*
CLR-5:	*impart the knowledge of thermal protection in power switches*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*acquire knowledge on power switching devices*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*illustrate the knowledge on current controlled devices*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*apply the concept of voltage controlled devices*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*assess the knowledge of protecting circuits for power devices*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*apply the knowledge of thermal protection in power electronic circuit*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Introduction	***9 Hour***
Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – (SOA); Device selection strategy – On-state and switching losses – EMI due to switching - Power diodes - Types, forward and reverse characteristics, switching characteristics – rating.	
Unit-2 - Current Controlled Devices	***9 Hour***
BJT's – Construction, static characteristics, switching characteristics; Negative temperature co-efficient and secondary breakdown; Power darlington - Thyristors – Physical and electrical principle underlying operating mode, Two transistor analogy – concept of latching; Gate and switching characteristics; converter grade and inverter grade and other types; series and parallel operation; comparison of BJT and Thyristor – steady state and dynamic models of BJT and Thyristor.	
Unit-3 - Voltage Controlled Devices	***9 Hour***
Introduction to Power MOSFETs and IGBTs – Principle of voltage controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs -Basics of GTO, MCT, FCT, RCT and IGCT.	
Unit-4 - Firing and Protecting Circuits	***9 Hour***
Necessity of isolation, pulse transformer, optocoupler – Gate drives circuit: SCR, MOSFET, IGBTs and base driving for power BJT. - Over voltage, over current and gate protections; Design of snubbers.	
Unit-5 - Thermal Protection	***9 Hour***
Introduction to Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour – phase cooling; Guidance for hear sink selection – Thermal resistance and impedance -Electrical analogy of thermal components, heat sink types and design – Mounting types.	

Learning Resources	1. *L.Umanand, "Power Electronics: Essentials and Applications", Wiley India, sixth edition, 2015.* 2. *Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hall India, fourth edition, 2004.*	3. *MD Singh, K.B Khanchandani, "Power Electronics", Tata McGraw Hill, second edition, 2001.* 4. *Mohan, Undcland and Robins, "Power Electronics – Concepts, applications and Design", John Wiley and Sons, fourth edition, 2000.* 5. *P.S.Bimbhra P.S., "Power Electronics", Khanna Publishers, sixth edition, 2018.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Kannan, Seshasayee Paper and Boards Limited*	1. *Dr. A. Venkatasen, NIT Puducherry*	1. *Dr. D. Karthikeyan, SRMIST*
2. *Mr. Kumaresan, NTPC Chennai*	2. *Dr. A. Balaji, SSN Chennai*	2. *Dr. R. Palanisamy, SRMIST*

Course Code	21EEE408T	Course Name	MEMS TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*acquire knowledge on the various MEMS products in engineering and its applications*
CLR-2:	*impart knowledge on the fundamentals of micro systems*
CLR-3:	*gain knowledge on the micro system design*
CLR-4:	*enumerate micro system fabrication methods*
CLR-5:	*analyze micro manufacturing techniques and simulation steps for micro devices*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Identify MEMS products in engineering and its applications*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-2:	*explain the fundamentals of micro systems*	*3*	-	-	-	*2*	-	-	-	-	-		-	-	*1*	-
CO-3:	*analyze mechanical thermal and fluid flow design*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	*1*	-
CO-4:	*apply the different fabrication methods for micro systems design*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	*1*	-
CO-5:	*apply the specific manufacturing technique for the micro devices and simulate the micro devices*	*3*	-	-	-	*3*	-	-	-	*2*	*2*	-	-	-	*1*	-

Unit-1 - MEMS and Microsystems	***9 Hour***
Overview - Typical MEMS micro system products – Applications of micro system: in automotive industries, in aerospace industries, in biomedical industry, in consumer product, in telecommunication industry - Case study of MEMS based energy harvesting devices application.	
Unit-2 - Fundamental Principles of Microsystems	***9 Hour***
Working principles of microsystems: Introduction - Micro sensor - Microactuator – MEMS with micro motor. Engineering science for micro fabrication design and fabrication: Introduction – Atomic structure of matter – Ions and ionization – Molecular theory of matter and inter molecular forces – Doping of Semiconductors – Diffusion process – Plasma physics - Electro chemistry. Case study on principles of MEMS based energy harvesting devices.	
Unit-3 - Design and Analysis	***9 Hour***
Introduction –Static bending of thin plates – Mechanical vibration analysis –Thermo mechanical analysis –Fracture mechanics analysis –Thin film mechanics –overview of finite element analysis - overview of heat conduction in solids – Heat conduction in multilayered thin films – Heat conduction in solids at sub- micrometer - Case study on finite element analysis of MEMS based energy harvesting devices.	
Unit-4 - Micro Systems Fabrication	***9 Hour***
Introduction –photolithography –Ion implantation- Diffusion -Oxidation – chemical vapour deposition- Physical vapour deposition: sputtering –Deposition by epitaxy- Etching-Summary of microfabrication - Case study on fabrication of MEMS based energy harvesting devices.	
Unit-5 - Micro Manufacturing	***9 Hour***
Introduction – Bulk micro manufacturing – Surface micromachining – LIGA process –Summary of micro manufacturing. Micro systems design: Introduction - Design considerations – Process design– Mechanical design – Mechanical design using finite element method –Design of Silicon die of a micro pressure sensor –Computer aided design of MEMS based energy harvesting devices.	

Learning Resources	1. *Tai Ran Hsu, "MEMS and Micro systems: Design and manufacture", Tata McGraw - Hill, 2017.* 2. *Marc Madou, "Fundamentals of micro fabrication", CRC Press, second edition, 2018.*	3. *Chang Liu, "Foundation of MEMS", Pearson, second edition, 2012.* 4. *Minhang Bao, "Analysis and Design Principles of MEMS devices", Elsevier, first edition, 2005.* 5. *Mahalik N P, "MEMS", Tata Mc-Graw Hill, fifth edition, 2013.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. B. Niranjith kumar, BHEL, Chennai*	1. *Dr. Suresh Perumal, IIT Jodhpur*	1. *Dr. Y. Jeyashree, SRMIST*
2. *Mr. M. Umasankar, BHEL, Andhra Pradesh*	2. *Dr. Paul Braineard, IIIT Andhra Pradesh*	2. *Dr. Femi R, SRMIST*

Course Code	21EEE409T	Course Name	AUTOMOTIVE SYSTEMS ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*outline the basics of automotive systems engineering*
CLR-2:	*discover the development process in automotive systems*
CLR-3:	*familiarize the concept of electrical/electronic (E/E) system development in automotive systems*
CLR-4:	*enrich the knowledge of developing the automotive software systems*
CLR-5:	*discover the importance of management processes during the development of automotive systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*enumerate the process involved in automotive systems engineering*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	-
CO-2:	*explain the vehicle development process of an EV and building a virtual vehicle with a product strategy*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*design, analysis, and validation of the E/E system in automobiles*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*understand the processes involved in the development and testing of automotive software systems*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*understand the management and process involved in the vehicle development*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction	***9 Hour***
Characteristics of Systems Engineering - Methods of System Engineering - Challenges for Systems Engineering - Perspectives in Vehicle Development – Evaluation - Test Bed Reference Sensors - Architectures in Vehicle Development - Methods and Tools for Simulation and Testing - Processes and Organizational Structure for System Design - Functional Safety - Automotive Systems Engineering in Research.	
Unit-2 - Vehicle Development Process	***9 Hour***
Categories of the vehicle development process - Introduction to Product Evolution Process (PEP) - Phases of the PEP - Initial phase - Concept phase - Series development and support phase - Process of the PEP - Building virtual cars - Geometric integration and evaluation - The V-model of product development – Product strategy.	
Unit-3 - Electrical/Electronic (E/E) System Development	***9 Hour***
Systems Engineering Processes - Requirements Engineering – Elicitation – Analysis – Documentation - Validation - System Architecture and Design - Logical System Architecture - Technical System Architecture - Component Development and Testing- Systems Integration and Validation - Supporting Management Processes - Capability Maturity Model Integration (CMMI).	
Unit-4 - Automotive Software Development	***9 Hour***
Requirements in Automotive Software Development – Types – Variant Management – Configuration – Compilation - Practical Variability Management - Integration Stages of Software Development – Testing Strategies – Unit – Component – System – Functional – Pragmatics of testing large software systems – Iterative testing – Role of construction database.	
Unit-5 - Management Processes for Complete Vehicle Development	***9 Hour***
Target management – Complete vehicle requirements - Target Agreement - Sign -off process - Design problem management - Release and Design changes - Change management – Engineering Change request - Quality management systems, Predelivery and post-delivery Quality Assessment – Quality costs.	

Learning Resources	1. *Markus M and Hermann Winner., "Automotive Systems Engineering", Springer, first edition, 2013.* 2. *Weber Julian, "Automotive Development Processes", Springer, first edition, 2009.*	3. *Russel C Hibler," Engineering Mechanics: Statics, Dynamics', Pearson, fourteenth edition, 2015* 4. *Daniel S., "The Automotive Development Process", Springer, first edition, 2006.* 5. *Miroslaw S., Automotive Software Architectures, Springer, first edition, 2017.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	*30%*	-	*30%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Vijayakumar Kesavan, Staqual Precision Private Ltd*	1. *Dr. T. Logeswaran, Kongu Engineering College, Erode*	1. *Dr. A. Geetha, SRMIST*
2. *Mr. Francis Suresh Balan, CGS Green Sustainergy Pvt. Ltd*	2. *Dr. M. Durairasan, University College of Engineering, Thirukkuvalai*	2. *Dr. C. Bharatiraja, SRMIST*

Course Code	21EEE410T	Course Name	AUTONOMOUS AND CONNECTED VEHICLES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamental theory and operation of automotive electronics and electronic control systems*
CLR-2:	*understand the fundamental principles of data networking and its role in advanced driver assistance systems (ADAS)*
CLR-3:	*understand the concept of the connected vehicle and its role in ADAS and automated vehicles*
CLR-4:	*study the possible evolution of autonomous vehicles prognostics and impaired driver technology*
CLR-5:	*understand the concept of cyber-physical control systems and their application to collision avoidance and autonomous vehicles*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the different configurations of autonomous vehicles*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*analyze data networking, advanced driver assistance systems (ADAS), and autonomous driving*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*acquire knowledge of the concept of the instrument clusters and sensors for autonomous and connected vehicles*	*2*	-	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*deploy vehicle prognostics and perception technology*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*familiarize the different connectivity, interaction networks and security of connected vehicles and automated vehicles*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Introduction to Automated, Connected, and Intelligent Vehicles — ***9 Hour***

Introduction to the Concept of Automotive Electronics: Automotive Electronics Overview- History & Evolution-Infotainment, Body, Chassis, and Powertrain Electronics- Advanced Driver Assistance Electronic Systems- Autonomous Driving Technologies Overview - Basic Intelligent Vehicles Control System - Overview of the Operation of ECUs - Role of Surroundings Sensing Systems and Autonomy, Role of Wireless Data Networks and Autonomy.

Unit-2 - Advanced Driver Assistance Systems (ADAS) and Autonomous Driving — ***9 Hour***

Autonomous Driving Algorithms -Autonomous Driving Client System – Integration of ADAS Technology into Vehicle Electronics -Autonomous Driving Cloud Platform - Vehicle Control: Cruise Control, Antilock Brake Systems, Steering Control and Lane Following, Parking – Connected Vehicles: Vehicle to Vehicle Communication, Vehicle to Infrastructure Communication- control Systems for Autonomous Driving: Model Predictive Control and IDP Controllers for autonomous driving system, their safety.

Unit-3 - Sensors for Autonomous and Connected Vehicles — ***9 Hour***

Sensor Technology for Advanced Driver Assistance Systems- Basics of Radar Technology and Systems - Ultrasonic Sonar Systems - Lidar Sensor Technology and Systems - Camera Technology -Night Vision Technology - Use of Sensor Data Fusion -Integration of Sensor Data to On-Board Control Systems- Connected Car Display Technology - Center Console Technology - Gauge Cluster Technology -Heads-Up Display Technology - Warning Technology – Driver Notifications.

Unit-4 - Vehicle Prognostics and Perception Technology	***9 Hour***
Vehicle Prognostics Technology -Monitoring of Vehicle Components -Basic Maintenance -End-of-Life Predictions -Advanced Driver Assistance System Sensor Alignment and Calibration Autonomous Vehicles - Driverless Car Technology - Moral, Legal, Roadblock Issues - Impaired Driver Technology - Driver Impairment Sensor Technology - Sensor Technology for Driver Impairment Detection - Transfer of Control Technology.	
Unit-5 - Autonomous Vehicles Security	***9 Hour***
Technical Issues –Security Issues - Sensing and smart vehicles: Driving, roads and pedestrians, highways vs. secondary roads. Connectivity and interaction with networks. Knowledge extraction from multiple sensors - Connected Car Display Technology - Center Console Technology - Gauge Cluster Technology -Heads-Up Display Technology - Warning Technology – Driver Notifications- cyber-physical Securities.	

Learning Resources	1. *G. Mullett, "Wireless Telecommunications Systems and Networks", Thomson,Delmar Learning, 2006.* 2. *Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean-Luc Gaudiot, "Creating Autonomous Vehicle Systems", Morgan and Claypool, 2018.* 3. *Umit Ozguner, Tankut Acarman, Keith Redmill, "Autonomous Ground Vehicles", Artech House, 2011.* 4. *G. Mullett," Basic Telecommunications: The Physical Layer", Thomson, Delmar Learning, 2003.*	5. *Hong Cheng, "Autonomous Intelligent Vehicles Theory, Algorithms, and Implementation", Springer, 2011.* 6. *Mohinder S. Grewal, Angus P. Andrews, Chris G. Bartone, "Global Navigation Satellite Systems, Inertial Navigation, and Integration", Third Edition, John Wiley and Sons, 2013.* 7. *S. Liu, L. Li, J. Tang, S. Wu, and J.-L. Gaudiot, "Creating Autonomous Vehicle Systems," Synthesis Lectures on Computer Science, 2018.* 8. *Larminie, James, and John Lowry, "Electric Vehicle Technology Explained", John Wiley and Sons, 2012.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Ms. Santhiya, Tataelxi, Bangalore, India*	1. *Dr. Sheldon Williamson, Ontario Tech University, Canada*	1. *Dr. C. Bharatiraja, SRMIST*
2. *Mr. Paul, HanKaiSi Intelligent Technology Co., Ltd., Guizhou, China*	2. *Dr. Hariharan Muthusamy, National Institute of Technology, Uttarakhand*	2. *Dr. K. Sivanathan, SRMIST*

Course Code	21EEE411T	Course Name	INTELLIGENT TRANSPORT SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the essentials of the intelligent transport system*
CLR-2:	*study the sensor technologies and navigation systems*
CLR-3:	*examine the usage of data based intelligent techniques to transportation*
CLR-4:	*familiarize with the system model and its evaluation*
CLR-5:	*understand the concept of public transport system*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the background of intelligent transport system (ITS) and its user services*	*3*	-	-	-	-	-	*1*	-	-	-	-	-	-	-	*1*
CO-2:	*examine the sensor technologies in traffic management and navigation systems*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	*2*	*2*	-
CO-3:	*identify the user services and data management using artificial intelligence*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*realize the architecture and development of intelligent transport system models*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*apply the concepts and pricing of freight and public transport systems*	*3*	-	-	*2*	-	*1*	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction of Intelligent Transport Systems (ITS) — ***9 Hour***

Fundamentals of ITS – Definition, historical context, public policy, market economic perspectives; Types of ITS; Benefits of ITS integration; ITS user needs, ITS user services; Groups of ITS user services and technologies.

Unit-2 - Sensors and Navigation Systems in Intelligent Transport Systems — ***9 Hour***

Sensor technologies and Data requirements of ITS; Importance of telecommunications in ITS, Traffic Management Centers (TMC), Application of sensors to Traffic management, Traffic flow sensor technologies, Sensor plan and specification requirements, Transponders and Navigation systems, Artificial intelligence in TMC and road safety, Artificial Intelligence in navigation systems.

Unit-3 - User Needs, Services and Data Collection Techniques — ***9 Hour***

ITS User Needs, Services and Functional areas; Real-time policy framework on ITS; ITS Data collection techniques - Detectors, Geographic Information System, and video data collection; Artificial Intelligence in data collection; Data driven transportation management.

Unit-4 - Architecture and Operation — ***9 Hour***

ITS Architecture –Regional and external Projects; Concept of operations; ITS Models and Evaluation Methods; Planning and human factor issues for ITS, Case studies on deployment planning and system design and operation; ITS safety and security, ITS as technology deployment program, development, and business models; ITS planning.

Unit-5 - Applications and Pricing — ***9 Hour***

Electronic toll collection, ITS road-pricing; Commercial vehicle operations and intermodal freight; public transportation applications; ITS regional strategic transportation planning: ITS and changing transportation institutions Automated Highway Systems, Integration of Automated Highway Systems. ITS Programs in the World, Overview of ITS implementation in developed countries.

Learning Resources	1. *Mashrur A. Chowdhury, Adel Wadid Sadek, "Fundamentals of intelligent transportation systems planning", Artech House Publisher, 2016.* 2. *Lawrence A. Klein, "Sensor technologies and Data requirements of ITS", Artech House Publisher, 2001.* 3. *Kan Paul Chen and John Miles, ITS Handbook: Recommendations for World Road Association, PIARC Publishers, 2000.*	4. *Evangelos Bekiaris and Yuko J. Nakanishi, "Economic Impacts of Intelligent Transportation Systems: Innovations and Case Studies", Elsevier Publisher, 2004.* 5. *Sussman, J. M, "Perspective on ITS", Artech House Publishers, 2005.* 6. *National IT'S Architecture Documentation, US Department of Transportation, 2007.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	*30%*	-	*30%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Bhaskarsahu, Schneider Electric Ltd.*	1. *Dr. K. S. Swarup, IIT Madras*	1. *Dr. Phani Teja Bankupalli, SRMIST*
2. *Mr. V. Selva Kumar, R&D, Ford India, Ltd., Chennai.*	2. *Dr. Hemachender,, NIT, Puducherry*	2. *Dr. C. Bharatiraja, SRMIST*

Course Code	21EEE412T	Course Name	TECHNO-ECONOMIC ANALYSIS OF ELECTRIC VEHICLES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the principles, components, and types of electric vehicles*
CLR-2:	*analyze the technological aspects of electric vehicles, including batteries, motors, power electronics, charging infrastructure, and energy storage*
CLR-3:	*evaluate the life cycle assessment, cost analysis, energy consumption and efficiency, carbon footprint, and environmental impact of electric vehicles*
CLR-4:	*identify the market trends, government policies, incentives, regulatory frameworks, and public perception of electric vehicles*
CLR-5:	*analyze case studies of electric vehicles and study the future trends of electric vehicles*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze basic configuration of electric vehicle*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*analyze the technological aspects of electric vehicles*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*acquire knowledge on economic analysis of EV*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*acquire knowledge on market trends and government policies*	*3*	-	-	-	-	-	*2*	-	-	-	-	-	-	*2*	-
CO-5:	*familiarize different electric vehicles using case studies and the future trends of electric vehicles*	*3*	-	-	-	-	-	*2*	-	-	-	-	-	-	*2*	-

Unit-1 - Introduction to Electric Vehicles ***9 Hour***

History of electric vehicles: from early electric car prototypes to current models- Types of electric vehicles: battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and hybrid electric vehicles (HEVs)- Comparison with conventional vehicles: advantages and disadvantages of electric vehicles compared to traditional gasoline-powered cars- Key components of an electric vehicle: battery pack, electric motor, power electronics, on-board charger, regenerative braking system.

Unit-2 - Technical Analysis of Electric Vehicles ***9 Hour***

Electric powertrain components: motor controller, inverter, gearbox, differential, axles- Battery technologies and charging systems: lithium-ion batteries, solid-state batteries, charging stations, charging time and range considerations- Power electronics and electric motors: brushless DC motors, induction motors, permanent magnet synchronous motors, power density and efficiency- Range, efficiency, and performance analysis: factors affecting electric vehicle range, energy efficiency metrics, acceleration, top speed, and handling performance

Unit-3 - Economic Analysis of Electric Vehicles ***9 Hour***

Total Cost of Ownership (TCO) analysis: upfront costs, fuel and maintenance savings, residual value, and financing options- Life-cycle assessment (LCA) of electric vehicles: environmental impact of electric vehicle manufacturing, use, and disposal-Policy incentives and regulatory environment: government subsidies, tax credits, and regulations promoting electric vehicle adoption- Business models for electric vehicle adoption: car sharing, ride-hailing, and subscription services- Carbon footprint analysis of electric vehicles.

Unit-4 - Market Analysis of Electric Vehicles ***9 Hour***

Global electric vehicle market trends and forecasts: sales volume and growth, regional market shares, and competitive landscape- Market segmentation and customer behavior: consumer demographics, purchase motivations, and brand preferences- Electric vehicle adoption barriers and opportunities: infrastructure availability, battery range anxiety, consumer education, and technology advancement- Electric vehicle supply chain analysis: key players, value chain, and technology innovation.

Unit-5 - Case Studies and Future Outlook	***9 Hour***
Techno-economic analysis of electric vehicle case studies: cost-benefit analysis, impact on local economies, and user experience- Comparison of different electric vehicle models: market positioning, features, and performance- Future trends in electric vehicle technology and market adoption: autonomous driving, vehicle-to-grid (V2G) integration, and innovation in battery technology- Challenges and opportunities for electric vehicles: energy storage, power grid integration, and environmental sustainability.	

Learning Resources	1. *Iqbal Husain, "Electric and Hybrid Vehicles: Design Fundamental", third edition, CRC Press, 2021.* 2. *James Larminie and John Lowry, "Electric Vehicle Technology: Exploring the Electric Vehicle Revolution", second edition, Wiley, 2012.* 3. *Gianfranco Pistoia, "Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure and the Market", first edition, Elsevier; 2010.*	4. *David Beeton, Gereon Meyer, "Electric Vehicle Business Models: Global Perspectives", first edition, Springer, 2019.* 5. *David L. Levy and Shanti Gamper-Rabindran, "Electric Vehicles in the Global Context: Experiences and Lessons from Seven Countries", first edition, MIT Press, 2018.* 6. *Yasuaki Sakamoto and Mark F. Miller, "Innovation in Electric Vehicle Technology", second edition, Springer, 2018.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Bhaskarsahu, Schneider Electric Ltd.*	1. *Dr. K. S. Swarup, IIT Madras*	1. *Dr. D. Sattianadan, SRMIST*
2. *Dr. D. Maharajan, Hitachi Energy, Chennai*	2. *Dr. P. Somasundaram, Anna University, Chennai*	2. *Dr. C. Bharatiraja, SRMIST*

Course Code	21EEE413J	Course Name	ELECTRIC VEHICLES POWER TRAIN MODELLING AND SIMULATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamentals of electric vehicles power train*
CLR-2:	*analyze the electric vehicles dynamics and transmission characteristics*
CLR-3:	*understand the modelling of electric vehicles power train*
CLR-4:	*analyze the modeling and simulation of electric vehicles power train batteries*
CLR-5:	*understand the modelling of thermal management system electric vehicles power train subsystems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*determine the modelling and characterization of electric vehicles power train*	*3*	-	-	*3*	*2*	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*familiarize electric vehicles dynamics*	*3*	-	-	*3*	*3*	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*design and development of electric vehicles power train subsystems*	*3*	-	-	*3*	*2*	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*acquire knowledge on modeling, design, and deployment of batteries in electric vehicles*	*3*	-	-	*3*	*3*	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*perform a software simulation of an electric vehicles power train with real-time thermal constraints*	*3*	-	-	*3*	*3*	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Fundamental of Electric Vehicles Power Train ***12 Hour***

Fundamental concept and components of EV Power Train - EV Power Train Classifications - Transmission and driveline systems - Vehicle layout with reference to Power Plant Location and drive systems, Types of chassis, Body styles, Classification of vehicle based on body types - Powertrain Components Selection. Nomenclature and Understanding Calculation for EV Components - Tradeoff analysis and component sizing - control parameter optimization.

Laboratory Practice: *Simulation on EV Power Train to validate the traction performance.*

Unit-2 - Electric Vehicles Power Train Dynamics ***12 Hour***

Basics of Vehicle Dynamics - Fundamental approaches to vehicle dynamics modeling - SAE Vehicle axis system, Forces, and Moments Affecting Vehicle - Earth Fixed coordinate system and Dynamic axle loads - Equations of motion - Transmission characteristics. Acceleration Performance Power train components: power and traction limited acceleration - transverse weight shift - front wheel drive vs rear wheel drive vs. all-wheel drive vehicles.

Laboratory Practice: *Simulation on EV All-Terrain Vehicle with Sims cape, EV 4 wheel Vehicle Dynamics Model.*

Unit-3 - Modelling Electric Vehicles Power Train ***12 Hour***

Electric Plant Subsystem – Four-wheel Powertrain System Model - Electric Vehicle Motor and Battery Sizing Calculation - Optimizing Vehicle Electrical Design through System Level Simulation - Quasi-static approach based powertrain modeling -Dynamic approach based powertrain modeling, Advanced transmission sizing and optimization - Driving Cycles Modelling and Analysis of Electric and Hybrid Electric Vehicles Propulsion and Braking - Vehicle Braking Modelling and Analysis -High-Fidelity Model of an Electric Motor for Control System Design and Verification - EV Powertrain design with Model-Based Development.

Laboratory Practice: *Simulation on EV All-Terrain Vehicle with Sims cape, EV 4-wheel Vehicle Dynamics Model.*

Unit-4 - Modeling Batteries and Simulation	***12 Hour***
Equivalent circuits to represent the dynamic behavior of a battery cell - Battery Data Acquisition and Analysis - Battery Modeling- Impact of Cell Temperature on Battery Aging -Modeling Battery Management Systems - Battery Thermal Management System Design - Model-Based Parameter Identification of Healthy and Aged Li-ion Batteries-Thermal Effect and Cooling system development - Li-ion cell modeling and Battery Management System modeling - Hardware-in-the-loop Battery and BMS testing for Electric Vehicle (HEV) Power Train.	
Laboratory Practice: *Electric Vehicle Modeling in MATLAB and Simulink with SoC and SoE Estimation of a Lithium-ion Battery.*	
Unit-5 - Thermal Management System	***12 Hour***
EV Thermal management systems - Battery Thermal Management System Design - Battery cooling and heating -Motor cooling systems - Power electronics cooling - HVAC system - Power conditioning and Filtering, Power, Voltage Conversion- Cooling system - Battery electric vehicle with liquid-cooled motor – Model based Design of EV motor control development time using simulation models to design and verify control algorithms - Electric Vehicle Powertrain Design Using 1-D simulation model.	
Laboratory Practice: *Electric Vehicle Thermal Model and Thermal Management System.*	

Learning Resources	1. *Amir Khajepour, Saber Fallah and AvestaGoodarzi, "Electric and Hybrid Vehicles-Technologies, Modelling and Control: A Mechatronic Approach", John Wiley & Sons Ltd, first edition, 2014.* 2. *Chris Mi, Abul Masrur & David Wenzhong Gao, "Hybrid electric Vehicle- Principles & Applications with Practical Properties", Wiley, 2011.* 3. *Ibrahim Dinçer, Halil S. Hamut and Nader Javani, "Thermal Management of Electric Vehicle Battery Systems", John Wiley& Sons Ltd, first edition, 2016.*	4. *Ali Emadi, "Handbook of Automotive Power Electronics and Drives", Taylor & Francis Group, first edition, USA, 2005.* 5. *Antoni Szumanowski, "Hybrid Electric Power Train Engineering and Technology: Modelling, Control, and Simulation", IGI Global, 2013.* 6. *M. Ehsani, Y. Gao, S. Longo, K. Ebrahim," Modern Electric, Hybrid Electric, and Fuel Cell Vehicles", third edition.* 7. *Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles Fundamentals, Theory, and Design, second edition", CRC Press, 2010.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*15%*	*30%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*15%*	*30%*	*-*
Level 3	*Apply*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 4	*Analyze*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 5	*Evaluate*	*10%*	*-*	*-*	*15%*	*-*	*-*
Level 6	*Create*	*10%*	*-*	*-*	*15%*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Hariram Satheesh, ABB Limited, India*	1. *Dr. Raghu Selvaraj, CSIR-Central Mechanical Engineering Research Institute (CMERI), India*	1. *Dr. C. Bharatiraja, SRMIST*
2. *Mr. Shivambhati, Rizelautomotive Pvt, India*	2. *Dr. Sheldon Williamson, Ontario Tech University, Canada*	2. *Dr. K. Vijayakumar, SRMIST*

Course Code	21EEE414J	Course Name	INDUSTRIAL ELECTRONICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*impart knowledge on the power factor correction unit in power electronic applications*
CLR-2:	*illustrate the working of sensor and circuits in industrial application*
CLR-3:	*analyze the principle industrial heating and welding*
CLR-4:	*impart knowledge on industrial AC and DC drives*
CLR-5:	*outline the concepts of PLC in industrial application*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the knowledge on the impact of rectifier units on power factor and harmonics*	*2*	-	-	-	*3*	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*apply concepts of sensing and control in industrial applications*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*impart the concepts of induction heating and welding in industrial applications*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*analyze the performance of industrial AC and DC drives*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*interpret the various concepts of PLC in industrial application*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Filter Design and Power Factor Correction — ***12 Hour***

Power supply -switched mode power supplies, performance parameters of power supplies -front end uncontrolled rectifier, Design of filters – active and passive – Impact of passive filters on power factor and harmonics. Power factor correction using dc-dc converter.

Laboratory Practice: *Development of power factor correction circuit using dc-dc converters.*

Unit-2 - Sensors and Integration — ***12 Hour***

Introduction to Electronic Sensors - Non-contact Sensors - Sensor Output Interfaces - Analog Automation Sensors - Sensor Applications and Selection - Integrating Sensors into Power and Control Circuits. Selection of Pressure, temperature, flow, level and RPM, Load sensor for industrial application. Selection of signal conditioning module for the sensors and interface with PLC.

Laboratory Practice: *Development of customized sensing circuits- voltage, current, Temperature, Pressure, Flow Sensors, Level Sensors, Position Sensors.*

Unit-3 - Induction Heating and Welding — ***12 Hour***

Industrial heating- types – Arc furnace, high frequency heating, High frequency source for induction heating, dielectric heating and microwave heating, Ultrasonic- Generation- Electronic welding control – types- timers used in resistive welding.

Laboratory Practice: *Development of resonant power converters for Induction Heating/welding applications*

Unit-4 - DC and AC Drives — ***12 Hour***

Steady state characteristic of DC motors – Control of DC motor using converters and choppers – Regenerative and dynamic braking – Closed loop control scheme – Speed-torque characteristic of induction moto Static stator voltage control – V/f control – Static rotor resistance control – Slip power recovery scheme – Self-control of synchronous motor. Operation of Steeper, servo and AC drives for industrial application. Configuration of Industrial Stepper, servo and AC Drives- Altivar and ATV solutions.

Laboratory Practice: *Solid state control of D.C motor, Servo and Induction motor*

Unit-5 - Programmable Logic Controller (PLC)	***12 Hour***
Functions, applications, advantages and disadvantages of PLC over conventional relay controllers, comparison of PLC with process control computer system, factors to be considered in selecting PLC, functional block diagram of PLC, microprocessor in PLC, memory, input and output modules (interface cards), sequence of operations in a PLC, status of PLC, event driven device, ladder logic language, simple process control applications of PLC, Configuration of DIO, AIO, Pulse counting and PWM cards in Unity ProX. .	
Laboratory Practice: *Development of Programmable controllers, ladder logics, PLC for motor drives.*	

Learning Resources	1. *Ned Mohan, Tore M. Undeland and William P. Robbins, "Power Electronics", John Wiley & Sons, third edition, 2007.* 2. *G. K. Mithal and Maneesha Gupta, "Industrial and Power Electronics", Khanna Publishers, Delhi, ninth edition, 2000.*	3. *L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, first edition, 2015.* 4. *B.K. Bose," Modern Power Electronics and AC Drives", Pearson Publications, 2008.* 5. *Dunningg, "Introduction to Programmable Logic Controllers", Cengage India, third edition, 2011.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. R. Parthipan, Igarashi Motors India Limited, Chennai*	1. *Dr. A. Venkadesan, NIT Puducherry*	1. *Dr. R. Sridhar, SRMIST*
2. *Mr. S.S. Biswas, Dept. of Atomic Energy, Kalpakkam*	2. *Dr. R. Ramesh, CEG, Chennai*	2. *Dr. J. Divya Navamani, SRMIST*

Course Code	21EEE415T	Course Name	VLSI CIRCUITS AND DESIGN	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand MOS technology in engineering and its applications*
CLR-2:	*understand CMOS technology with design rules and scaling*
CLR-3:	*design CMOS circuits to realize efficient digital functions*
CLR-4:	*explore characteristics of CMOS circuit and testing principles*
CLR-5:	*determine power dissipation in CMOS and efficient design system*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze MOS technology with its electrical properties*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*determine various VLSI circuit design processes and packaging technology*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*demonstrate basic circuit concepts of gate level design*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*design and implement various VLSI logical circuits*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*apply low power technique concepts in various applications and perform testing*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Introduction to MOS Technology	***9 Hour***
Basic steps of IC fabrication, Introduction to MOS technology, Basic concepts of CMOS, BiCMOS and Power-Delay Tradeoffs, CMOS Inverter analysis and design	
Unit-2 - VLSI Circuit Design Processes	***9 Hour***
Introduction, MOS Layers, Stick Diagrams, Design Rules, Layout Diagrams, Scaling of MOS circuits, Limitations of Scaling, VLSI design Packaging Technology.	
Unit-3 - Gate Level Design	***9 Hour***
Logic gates, Basic Circuit Concepts, Area Capacitances calculations, Fan-in and fan-out, Gate-level power optimization techniques, Power Optimization for Sleep Mode.	
Unit-4 - Subsystem Design	***9 Hour***
Subsystem optimization, Shifters, Adders, ALUs, Multipliers, Parity generators, Comparators, Counters, High-Density Memory, and VLSI Design styles.	
Unit-5 - Low Power Design and CMOS Testing	***9 Hour***
Sources of Power Dissipation, Design for Low Power, Multiple Vth techniques, Dynamic Vth techniques, CMOS testing.	

Learning Resources	
	1. *Pucknell, D. A, Eshraghian, K & Esraghian, S, "Essentials of VLSI Circuits and Systems", Prentice-Hall of India, first edition, 2005.*
	2. *S. M. Sze," VLSI Technology", Tata McGraw Hill, second edition, 2003.*
	3. *Wayne Wolf, "Modern VLSI Design: IP-Based Design", Prentice Hall, Boston, 4th ed, 2009.*
	4. *Sung-Mo Kang, Yusuf Leblebici, Chulwoo Kim, "CMOS Digital Integrated Circuits, Analysis and Design", McGraw Hill Education, fourth edition, 2019.*
	5. *Neil H. E Weste, "Principles of CMOS VLSI Design: A System Perspective", Pearson Education, third edition, 2007.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Kusuma Eshwar, Danfoss industries Pvt ltd	*1. Dr. K V Praveen Kumar, SVNIT Surat*	*1. Dr. Ravi Eswar K M, SRMIST*
2. Dr. Patnana Hema Kumar, Hella India Automotive Private Ltd	*2. Dr. Hari Priya Vemuganti, NIT Raipur*	*2. Dr. R. Uthra, SRMIST*

Course Code	21EEE416T	Course Name	MEDICAL ELECTRONICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*acquire knowledge on the principles of physiology and bio-potential recording*
CLR-2:	*learn about the various parameters and assist measurements in bio medical field*
CLR-3:	*expose the various physical medicine and biotelemetry recent trends in medical instruments*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the human body electro and non-electro recording*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*elicit the concepts of bio-potentials physiological parameters and assist devices*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*acquire a comprehend physical medicine methods and recent trends in medical instruments*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Electro Physiology	***9 Hour***
Review of physiology and anatomy, resting potential, action potential, bioelectric potentials, electrode theory, bipolar and uni-polar electrodes, surface electrodes, needle electrode and microelectrode, physiological transducers-selection criteria and its application.	
Unit-2 - Bioelectric Potential and Cardiovascular Measurements	***9 Hour***
ECG recording system, Heart sound measurement-stethoscope, phonocardiograph (PCG), Foetalmonitor- ECG-phonocardiography, vector cardiograph, cardiac arrhythmia's monitoring system. EMG, EEG - Evoked potential response, ERG and EOG recording system. Measurement of blood pressure using sphygmomanometer instrument based on Korotkoff sound, indirect measurement of blood pressure, automated indirect measurement, and direct measurement techniques.	
Unit-3 - Clinical Laboratory Equipment	***9 Hour***
Chemical tests in clinical laboratory, Automated Biochemical Analysis System. Blood gas analyzer, Acid –base balance, Blood PH measurement, blood PCO2, blood PO2, Intra –arterial blood gas analyzers, Blood cell counters- types of blood cells, - methods of cell counting –coulter counter- Automatic recognition and differential blood cell counting	
Unit-4 - Respiratory and Pulmonary Measurements	***9 Hour***
Physiology of respiratory system, respiratory rate measurement- artificial respirator- oximeter, pulmonary function measurements–spirometer–photo plethysmography and body plethysmography. Principal and techniques of impedance pneumography, Apnea monitor.	
Unit-5 - Recent Trends in Medical Instrumentation	***9 Hour***
Telemedicine, Insulin Pumps, Radio pill, Endo microscopy, Brain machine interface, intelligent medical instrument systems	

Learning Resources	1. *John G.Webster, John W Clark,jr," Medical Instrumentation Application & Design", John Wiley & sons, New York, fourth edition, 2010.* 2. *Arthur Guyton, John E. Hall, "Text Book of Medical Physiology", Elsevier Saunders, twelfth edition, 2011.*	3. *Leslie Cromwell, Fred J. Weibell and Erich A. Pfeiffer," Biomedical Instrumentation and Measurements", Prentice Hall of India, New Delhi, fifth edition, 2014.* 4. *Jerry. L.Prince, Jonathan M. Links," Medical Imaging Signals and Systems", Pearson Prentice Hall, second edition, 2015.* 5. *Shakti Chatterjee and Aubert Miller, "Biomedical Instrumentation Systems", CENGAGE Learning publishing, second edition, 2016.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Bhaskarsahu, Schneider Electric Ltd.*	1. *Dr. K. S. Swarup, IIT Madras*	1. *Dr. R. Brindha, SRMIST*
2. *Mr. M. Praveen, Perfint Healthcare Pvt.Ltd.*	2. *Dr. A. R. Jac Fredo, IIT (BHU)*	2. *Dr. R. Uthra, SRMIST*

Course Code	21EEE417T	Course Name	PRINCIPLES OF DIGITAL COMMUNICATIONS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	acquire fundamental concepts of communications and its characteristics
CLR-2:	focus on the various analog communication systems and pulse modulations
CLR-3:	expose the various types of digital modulation and wave coding

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	design PCM systems, waveform coding and baseband transmission schemes	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO-2:	analyze the characteristic of analog communications and different pulse modulation scheme and digital modulation scheme	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO-3:	elicit the concepts of the various types of digital modulation and wave coding	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-

Unit-1 - Review of Fundamental Concepts	**9 Hour**
Elements of an electrical communication system; Characteristics of communication channel and their mathematical modeling; Signal models: deterministic and random; signal classification; Fourier series representation, Parseval's theorem; Fourier transform; Hilbert transform; Random Process: mean, correlation and covariance; stationary and ergodic processes	
Unit-2 - Analog Communication System	**9 Hour**
Concept of modulation and demodulation, Continuous wave (CW) modulation: amplitude modulation (AM) - double sideband suppressed carrier (DSBSC); single sideband (SSB) and vestigial sideband (VSB) modulation, Angle modulation - phase modulation (PM) and frequency modulation (FM); narrow and wideband FM. Representation of narrowband noise; receiver model, signal to noise ratio (SNR), noise figure, noise temperature, noise in DSB-SC, SSB, AM & FM receivers, pre-emphasis and de-emphasis.	
Unit-3 - Pulse Modulation	**9 Hour**
Sampling process, sampling theorem for band limited signals; pulse amplitude modulation (PAM); pulse width modulation (PWM); pulse position modulation (PPM); pulse code modulation (PCM); differential pulse code modulation; delta modulation and adaptive delta modulation line coding. Basics of time division multiplexing, noise consideration in PCM systems	
Unit-4 - Basic Digital Modulation Schemes and Signaling over AWGN Channels	**9 Hour**
Overview of geometric representation of signals, Gram-Schmidt Orthogonalization procedure; Basic digital modulations schemes: Phase shift keying (PSK), amplitude shift keying (ASK), frequency shift keying (FSK) and Quadrature amplitude modulation (QAM); coherent demodulation and detection; probability of error. Basics of equivalent complex baseband representation of digitally modulated signals.	
Unit-5 - Information Theory	**9 Hour**
Discrete Memory less source, Information, Entropy, Mutual Information – Discrete Memoryless channels – Binary Symmetric Channel, Channel Capacity – Hartley – Shannon law – Source coding theorem – Shannon – Fano and Huffman codes.	

Learning Resources	1. *Simon Haykin, "Digital Communication", Wiley, Reprint, second Edition, 2013.* 2. *Bernard Sklar, "Digital Communications - Fundamentals and Applications", Pearson Education (Asia) Pvt. Ltd, second Edition, 2014.* 3. *H P Hsu, Schaum Outline Series,"Analog and Digital Communications", TMH,7th ed , 2006.*	4. *B.P.Lathi, "Modern Digital and Analog Communication Systems", Oxford University Press, third edition, 2007.* 5. *J.G Proakis," Digital Communication", Tata Mc Graw Hill Company, fourth edition, 2001.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. Bhaskarsahu, Schneider Electric Ltd.*	1. *Dr. K. S. Swarup, IIT Madras*	1. *Dr. R. Brindha, SRMIST*
2. *Mr. K. Chandrasekaran, DRDO*	2. *Dr. V. Noor Mohammed, VIT*	2. *Dr. R. Uthra, SRMIST*

Course Code	21EEE418T	Course Name	DEVICE MODELLING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21EEC201J*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*apply the physics involved in the modeling of BJT devices at higher frequencies*
CLR-2:	*understand the advances in MOSFET and device models*
CLR-3:	*explore the AlGaN/GaN HEMT device and characteristics*
CLR-4:	*understand the small signal modeling of AlGaN/GaN HEMT device*
CLR-5:	*acquire knowledge large signal modeling of AlGaN/GaN HEMT device*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*articulate the physics behind device modeling of advanced BJT*	*3*	*1*	-	-	*1*	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*illustrate the characteristics and models of advanced MOSFET*	*3*	*1*	-	-	*1*	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*demonstrate the operation and characteristics of AlGaN/GaN HEMT device*	*3*	*1*	-	-	*1*	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*create small signal modeling of GaN device*	*3*	*1*	-	-	*1*	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*analyze the large signal modeling of GaN device*	*3*	*1*	-	-	*1*	-	-	-	-	-	-	-	*1*	-	-

Unit-1 - Advanced BJT	***9 Hour***
Operation of the BJT at High Frequencies, Charge Control Model, Small Signal Equivalent Circuit, Design of High Frequency Transistors, Second Order Effects in BJTs, Non-uniform Doping in the Base—Improvement in Base Transit Time, High Injection in Collector, Heavy Doping Effects in the Emitter, Emitter Crowding in Bipolar Transistors, Nonconventional BJTs, Polysilicon Emitter Transistor, Heterojunction Bipolar Transistors (HBT).	
Unit-2 - Advanced MOSFET	***9 Hour***
Effect of Gate and Drain Voltages on Carrier Mobility in the Inversion Layer in MOSFET, Effect of Gate Voltage and drain voltage on Carrier Mobility, Channel Length Modulation, MOSFET Breakdown and Punch-through, Subthreshold Current, MOSFET Scaling, Non uniform Doping in the Channel, Threshold Voltage of Short-channel MOSFETs, Small Signal Analysis, Meyer's Model, Small Signal Equivalent Circuit of MOSFET Amplifier, SOI MOSFET, Buried Channel MOSFET.	
Unit-3 - AlGaN/GaN HEMT Device	***9 Hour***
AlGaN/GaN HEMT Device-operation, stricture, technology, fabrication, performance; Device Modeling approaches-physical, empirical; Bottom-up modeling technique, Device characterization, S-parameter measurements, Low frequency dispersion measurements.	
Unit-4 - Small Signal Modeling of AlGaN/GaN HEMT	***9 Hour***
AlGaN/GaN HEMT Small-Signal modeling, distributed small signal Equivalent Circuit Model, Extrinsic Parameter Extraction, generation of starting value of small signal model parameter, Model Parameter Optimization, Intrinsic Parameter Extraction, Small-Signal Model Verification, physical validation, Small-Signal Model Scaling.	
Unit-5 - Large Signal Modeling of AlGaN / GaN HEMT	***9 Hour***
AlGaN/GaN HEMT Large-Signal Modeling, Large-Signal Model Equivalent Circuit, Gate Charge Modeling, Gate Current Modeling, Drain Current Modeling, Dispersive Table-Based Drain Current Model, Trapping and Self-Heating Effects, Drain Current Model Fitting Parameter Extraction, Large-Signal Model Implementation, S-Parameter, IV Characteristics.	

Learning Resources	1. *A Dasgupta, N. Dasgupta, "Semiconductor Devices: Modeling and Technology", Prentice Hall India Private Limited, seventh edition, 2011.* 2. *Anwar Hasan Jarndal, "Large-Signal Modeling of GaN Devices for High Power Amplifier Design", Kassel University press, first edition, 2007.*	3. *Neil W. Ashcroft, N. David Mermin, "Solid State Physics", Cengage Learning, third edition, 2022.* 4. *Yannis Tsividis, "Operation and modeling of the MOS transistor", Oxford University Press, third edition, 2010.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 2	*Understand*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 3	*Apply*	*20%*	*-*	*25%*	*-*	*20%*	*-*
Level 4	*Analyze*	*20%*	*-*	*25%*	*-*	*20%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Akash Neel Dey, ST Microelectronics*	1. *Dr. Navjeet Bagga, IIT Bhubaneswar*	1. *Dr. R. Femi, SRMIST*
2. *Mr. Shreeprasad Sudhir Phadke, NXP Semiconductors*	2. *Dr. Anand. D. Darji, IIT Bombay*	2. *Dr. R. Uthra, SRMIST*

Course Code	21EEE419P	Course Name	FUNDAMENTALS OF VIRTUAL REALITY AND AUGMENTED REALITY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							1	0	4	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*impart knowledge on the virtual reality concept to build engineering applications*
CLR-2:	*experiment with the theory of representing the virtual world and VR development process*
CLR-3:	*design and develop the augmented reality concept and devices to build engineering applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the virtual reality to meet given specifications with realistic engineering constraints*	*3*	*2*	*-*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
CO-2:	*design and implement the VR development process*	*3*	*3*	*3*	*3*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
CO-3:	*design, develop and demonstrate the augmented reality project to meet given specifications with realistic engineering constraints*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*2*	*3*	*3*	*1*

Unit-1 - Introduction to Virtual Reality and Augmented Reality ***15 Hour***

Fundamental concept, Primary features and present development on virtual reality - Key characteristics and types of VR - Virtual reality as a discipline - Architecture of VR systems - Commercial VR technology and the five classic components of a VR system - Input devices and output devices. Representation of the virtual world - Changing position and orientation - Axis-angle representations of rotation - Viewing transformations - Chaining the transformations- Human eye- Kinematics modeling- Physical and Behavior modelling. Fundamental concept and components of augmented reality - The relationship between augmented reality and other technologies - Other ideas related to the spectrum between real and virtual worlds - System structure of augmented reality - Key technology in AR - Pattern recognition. Fundamentals of scene Generator – AR Devices: Optical See- HMD - Virtual retinal systems - Projection displays –Detection of surfaces and identifying feature point - Track virtual objects in real world - Face and object tracking. VR and AR development process for Science and Engineering, Health and Medicine, and Robotics applications.

Laboratory Practice and Project Design ***60 Hour***

Laboratory Practice: *Experiments on Graphics displays, Sound displays, haptic feedback from output device and three-dimensional position trackers from the input device using unity software -Perform the physical modelling and behavior modelling of VR development process - Experiment on the Eye movements & implications for VR and also Develop the augmented reality unity software for engineering application - Perform the experiment on AR Toolkit , generating a scene using unity AR components ,Track virtual objects in real world using unity AR concepts, VR and AR technology in physical exercises and games and VR and AR technology in the Social Considerations.*

Project Design: *The students should work as a team of not more than 3 to develop an VR and AR real time Project which involve:*

- *Designing, developing, coding, demonstrating, implementing VR and AR projects and preparing a formatted report on the project.*
- *Identifying the real time problem and find ways to apply engineering to solve*
- *Establish competence in the teamwork, finance and management of a real time project*
- *Demonstrating mastery in technical writing and presentation skills*
- *Get to know the required engineering and ethical standards*
- *Demonstrating familiarity in considering multiple realistic constraints (e.g., economic, environmental, sustainability, manufacturability, ethical, health and safety, social and political issues) while carrying out their design and future directions*

Learning Resources	1. *C. Burdea & Philippe Coiffet, "Virtual Reality Technology", Gregory, John Wiley and Sons, Inc, second edition, 2008.* 2. *Allan Fowle,"AR Game Development", A press Publications, first edition, 2018*	3. *Steve Aukstakalnis, "Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR", Addison-Wesley Professional, first edition, 2016.* 4. *William Sherif, "Learning C++ by Creating Games with UE4 ", Packt Publishing, 2015.* 5. *https://www.frontiersin.org/articles/10.3389/fpsyg.2018.02086/full*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		Formative CLA-1 Average of unit test (20%)		*Project Based Learning CLA-2 (60%)*		*Report and Viva Voce (20%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	-	*5%*	-	*30%*	-	-
Level 2	*Understand*	*30%*	-	-	*5%*	-	*30%*	-	-
Level 3	*Apply*	*20%*	-	-	*15%*	-	*20%*	-	-
Level 4	*Analyze*	*20%*	-	-	*15%*	-	*20%*	-	-
Level 5	*Evaluate*	-	-	-	*30%*	-	-	-	-
Level 6	*Create*	-	-	-	*30%*	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*		-	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Francis Suresh Balan, CGS Green Sustainergy Pvt Ltd,Chennai	*1. Dr. T. Logeswaran, Kongu Engineering College, Erode*	*1. Dr. S. Usha, SRMIST*
2. Mr. S. Saravanan, S&S Engineering, Chennai	*2. Dr. M. Durairasan, University College of Engineering, Thirukkuvalai*	*2. Dr. U. Sowmmiya, SRMIST*

Course Code	21EEE420J	Course Name	BIG DATA TOOLS FOR VISUALIZATION AND ANALYTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*enumerate the basics of statistics for data analysis*
CLR-2:	*articulate on various big data tools and Hadoop technology*
CLR-3:	*examine the data pre-processing, visualization, and analytics methodologies*
CLR-4:	*outline the data security and intrusion detection systems*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*interpret the basics on statistical learning techniques*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	*1*	-
CO-2:	*associate various big data tools and Hadoop technology*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*examine the data pre-processing, visualization, and analytics methodologies*	*3*	*2*	-	-	*2*	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*elaborate on the data security and intrusion detection systems*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Statistics for Big Data ***12 Hour***

Introduction to Learning through Big Data Platform and Analysis, Challenges of Big data, Data analysis, data analyst, data scientist, Characteristics of Big data, Examples of Big Data in various domain, Statistical Analysis – Introduction, Statistical Analysis – Need, Advantages, Scope, Nature and types of data, Statistical Analysis Software & Tools, Types of Statistical Analysis-Descriptive and Inferential, Statistical Analysis Techniques- Data Sampling, Sample size determination, Central Tendency, Random Variables, Probability Distributions, Statistical Inference, standard deviation, Confidence Intervals

Laboratory Practice*: For a given dataset, perform various statistical analysis*

Unit-2 - Big Data Tools ***9 Hour***

Technical elements of the Big Data platform, Analytics Toolkit, Components of the analytics toolkit, Distributed and Parallel Computing for Big Data, Cloud computing and Big Data, In-Memory Computing Technology for Big Data, Fundamentals of Hadoop, Hadoop Ecosystem, MapReduce, HDFS, YARN, Limitations of Hadoop and overcoming the limitations, Apache PIG, Hive, HBase, Other big data tools

Unit-3 - Data Preprocessing ***15 Hour***

Data types – structured, unstructured, semi structured, data import and export, Staging and Curating the data, Exploring and cleaning the data, Traditional methods for dealing with missing data, Maximum Likelihood Estimation – Basics, Missing data handling, Improving the accuracy of analysis, Introduction to Bayesian Estimation, Multiple Imputation-Imputation Phase, Analysis and Pooling Phase, Practical Issues in Multiple Imputation, Models for Missing Notation Random Data

Laboratory Practice: *For a given dataset, perform data-preprocessing*

Unit-4 - Data Visualization and Analysis ***15 Hour***

Data visualization plots, Attributes and Data Types, Vectors, Arrays and Matrices, Data Frames, Model building, Evaluation and Deployment, Various visualizations and analysis of plots, Hypotheses Testing, Null hypotheses and Alternative hypotheses, Difference of means Student t-test, Welch's t-test, Wilcoxon Rank-Sum test, Type I and II errors, Extreme Value Analysis, Clustering based, Distance Based and Density Based outlier analysis, Outlier Detection in Categorical Data

Laboratory Practice: *For a given dataset, perform data visualization and analyze the response*

Unit-5 - Data Security	***9 Hour***
Database Management Systems, Information Security Architecture, Introduction to Security Analytics, Challenges in Security Analytics, Concepts in Data Analytics Scenarios in Intrusion, Challenges in Intrusion, Incident Identification, Security Components, Authentication Methods, User Administration, Password Policies	

Learning Resources	
1. *Pratap Dangeti, "Statistics for Machine Learning", Packt Publishing Ltd., first edition, 2017.* 2. *Tom White, Hadoop, "The Definitive Guide", O'Reilly, fourth edition, 2012.* 3. *Michael Jambu,"Exploratory and multivariate data analysis",Academic Press Inc,1st ed, 1990.*	4. *Craig K. Enders, "Applied Missing Data Analysis", The Guilford Press, second edition, 2010.* 5. *Hassan A. Afyouni, "Database Security and Auditing", Third Edition, Cengage Learning, 2009.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*25%*	*-*	*-*	*15%*	*20%*	*-*
Level 2	*Understand*	*25%*	*-*	*-*	*15%*	*20%*	*-*
Level 3	*Apply*	*20%*	*-*	*-*	*35%*	*20%*	*-*
Level 4	*Analyze*	*20%*	*-*	*-*	*30%*	*20%*	*-*
Level 5	*Evaluate*	*10%*	*-*	*-*	*5%*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Karthick Logaraj, Cognizant Technology Solutions*	1. *Dr. D. Devaraj, KARE*	1. *Dr. U. Sowmmiya, SRMIST*
2. *Ms. Rajalakshmi, Capgemini*	2. *Dr. A Venkadesan, NIT Puducherry*	2. *Dr. J. Preetha Roselyn, SRMIST*

Course Code	21EEE421J	Course Name	STATISTICAL MACHINE LEARNING TECHNIQUES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the basics of statistics and machine learning techniques*
CLR-2:	*articulate on linear regression models, random forest, KNN, naive bayes and SVM*
CLR-3:	*examine the K-means clustering techniques and feature selection methods like PCA and SVD*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*interpret the basics on statistical machine learning techniques*	*3*	-	-	*1*	*2*	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*execute a model based on logistic regression, random forest, KNN, naive bayes and SVM*	*3*	-	-	*2*	*3*	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*organize the clustering analysis and feature selection through K-means clustering and PCA, SVD with scikit-learn*	*3*	-	-	*2*	*3*	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Statistics and Machine Learning ***12 Hour***

Statistical terminology for model building and validation-Machine Learning, Major differences between statistical modeling and machine learning, Steps in machine learning model development and deployment, Statistical fundamentals and terminology for model building and validation, Bias versus variance trade-off, Train and test data, Linear regression versus gradient descent, Machine learning losses, When to stop tuning machine learning models, Train, validation, and test data Cross-validation and its techniques, K-Fold, Grid Search, Machine learning model overview.

Laboratory Practice*: Perform statistical analysis and data preprocessing methods.*

Unit-2 - Regression Methods and Random Forest Algorithm ***12 Hour***

Comparison between regression and machine learning models, Compensating factors in machine learning models, Assumptions of linear regression Steps applied in linear regression modeling, Example of simple linear regression from first principles, Machine learning models - ridge and lasso regression-Example of ridge regression machine learning, Example of lasso regression machine learning model, Logistic Regression Versus Random Forest-Maximum likelihood estimation, Terminology involved in logistic regression, Applying steps in logistic regression modeling, Random forest-Example of random forest, Grid search on random forest, Variable importance plot, Comparison of logistic regression with random forest.

Laboratory Practice: *Perform regression analysis and random forest-based accuracy analysis.*

Unit-3 – KNN and Naïve Bayes Algorithm ***12 Hour***

K-nearest neighbors-KNN voter example, Curse of dimensionality-Curse of dimensionality with 1D, 2D, and 3D example, Curse of dimensionality with 3D example, KNN classifier with data example, Naive Bayes-Introduction, Probability Fundamentals-Joint probability, Understanding Bayes theorem with conditional probability, Naive Bayes classification, and Laplace estimator.

Laboratory Practice: *Perform KNN and Naïve Bayes based classification and accuracy analysis.*

Unit-4 - SVM Algorithm ***12 Hour***

Introduction to Support Vector Machines, Difference between Support Vector Machines and Neural Networks, Working principle of Support Vector Machines, Maximum margin classifier, Support vector classifier, Kernel functions for Support Vector Machines.

Laboratory Practice: *Perform SVM based classification and accuracy analysis*

Unit-5 - Clustering and Feature Selection Methods	***12 Hour***
Clustering-Introduction, Hierarchical clustering, K-means clustering-K-means working methodology from first principles, Optimal number of clusters and cluster evaluation, The elbow method, K-means clustering with example, Importance of Feature Selection and reduction, Methods, Principal component analysis – PCA working methodology from first principles, PCA applied on handwritten digits using scikit-learn, Singular value decomposition – SVD, SVD applied on handwritten digits using scikit-learn.	
Laboratory Practice: *Perform clustering analysis for the given data set; Perform feature selection and find the accuracy of the given data set using conventional machine learning algorithms.*	

Learning Resources	1. *Pratap Dangeti, "Statistics for Machine Learning", Packt Publishing Ltd, first edition, 2017.* 2. *Masashi Sugiyama, "Introduction to Statistical Machine Learning", Elsevier, first edition, 2016.*	3. *Gareth James, Daniela Witten,Trevor Hastie and Robert Tibshirani, "An Introduction to Statistical Learning with Applications in R", Springer, second edition, 2015.* 4. *Hastie Trevor, "The Elements of Statistical Learning: Data Mining, Inference, and Prediction", Springer-Verlag, second edition, 2009.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*-*	*5%*	*20%*	*-*
Level 2	*Understand*	*25%*	*-*	*-*	*20%*	*20%*	*-*
Level 3	*Apply*	*20%*	*-*	*-*	*25%*	*20%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*40%*	*20%*	*-*
Level 5	*Evaluate*	*10%*	*-*	*-*	*10%*	*10%*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Karthick Logaraj, Cognizant Technology Solutions*	1. *Dr. D. Devaraj, Professor, KARE*	1. *Dr. U. Sowmmiya, SRMIST*
2. *Ms. Rajalakshmi, Capgemini*	2. *Dr. A. Venkadesan, NIT Puducherry*	2. *Dr. J. Preetha Roselyn, SRMIST*

Course Code	21EEE422T	Course Name	DEEP LEARNING ALGORITHMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*introduce machine learning basics in engineering problems and its applications*
CLR-2:	*acquire the concept of different deep learning architecture*
CLR-3:	*model the deep learning network using transfer learning techniques*
CLR-4:	*design and develop the deep generated models*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*recognize the characteristics of machine learning models*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*identify and apply appropriate deep learning algorithm for analyzing real world problem*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*elucidate the concept of convolutional neural network and transfer learning techniques*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*access the efficacy of the deep generated models*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Machine Learning Basics	***9 Hour***
Introduction-Learning algorithms, Maximum likelihood estimation, Building machine learning algorithm, Neural Networks Multilayer Perceptron, Back-propagation algorithm and its variants Stochastic gradient decent, Curse of Dimensionality, Scalars, Vectors, matrices and Tensors. Feature Descriptor-Bayesian Learning, Decision Surfaces, Discriminant Function-Linear Classifiers, Linear Machines with Hinge Loss	
Unit-2 - Deep Learning Architectures	***9 Hour***
Machine Learning and Deep Learning, Representation Learning, Width and Depth of Neural Networks, Activation Functions: RELU, LRELU, ERELU, Unsupervised Training of Neural Networks, Restricted Boltzmann Machines, Auto Encoders, Deep Learning Applications. Support Vector machines- Linear machines- Multi class support vector machines-Optimization- Optimization Techniques in machine learning, Gradient Descent, Batch Optimization Nonlinear Functions-Introduction to Neural Networks-Multilayer Perceptron-backpropagation learning- examples. Unsupervised learning with Deep networks- Auto encoders, Auto encoders vs PCA	
Unit-3 - Convolutional Neural Networks	***9 Hour***
Architectural Overview, Motivation, Layers, Filters, Parameter sharing, Regularization, Popular CNN Architectures: AlexNet – Applications Convolutional Neural Network, Google Net, Resnet, Skip Connection Network, Fully Connected CNN, Optimizers: Effective training in Deep Net- early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization	
Unit-4 - Transfer Learning and Sequence Modelling	***9 Hour***
Transfer Learning Techniques, Recurrent Neural Networks, Bidirectional RNNs, Encoder-decoder sequence to sequence architectures - BPTT for training RNN, Long Short-Term Memory Networks., Classical Supervised Tasks with Deep Learning, Image Denoising, Semantic Segmentation, Object Detection, LSTM Networks	
Unit-5 - Deep Generative Models	***9 Hour***
Deep Belief networks, Boltzmann Machines, Deep Boltzmann Machine, and Generative Adversial Networks. Generative Modeling with DL, Variational autoencoder, Generative Adversarial Network Revisiting Gradient Descent, Momentum Optimizer, RMS Prop, Adam, Recent Trends.	

Learning Resources	1. *Ian Goodfelllow, Yoshua Benjio, Aaron Courville ,"Deep Learning",The MIT Press,1st ed, 2016.* 2. *Richard O. Duda, Peter E. Hart, David G. Stork, "Pattern Classification", John Wiley & Sons Inc, second edition, 2007.* 3. *Phil Kim, "Matlab Deep Learning: With Machine Learning, Neural Networks and Artificial Intelligence", A press, first edition, 2017.*	4. *Ragav Venkatesan, Baoxin Li, "Convolutional Neural Networks in Visual Computing", CRC Press, first edition, 2018.* 5. *Navin Kumar Manaswi, "Deep Learning with Applications Using Python", Apress, first edition, 2018.* 6. *Umberto Michelucci, "Applied Deep Learning. A Case-based Approach to Understanding Deep Neural Networks", a press, first edition, 2018.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. P V Manikandan, Intel Technology India Pvt Ltd.*	1. *Dr. K. S. Swarup, IIT Madras*	1. *Dr. N. Kalaiarasi, SRMIST*
2. *Ms. Saranya, Samsung Technology Ltd*	2. *Dr. R. Subha, M S Ramaiah Institute of Technology*	2. *Dr. U. Sowmmiya, SRMIST*

Course Code	21EEE423T	Course Name	EDGE COMPUTING TECHNOLOGIES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*outline the basic concept of edge computing*
CLR-2:	*summarize key components of edge computing architecture*
CLR-3:	*demonstrate the effectiveness of edge computing in internet of thing (IoT)*
CLR-4:	*illustrate the concept of multi-access edge computing technology (MEC)*
CLR-5:	*implement the edge computing application for electrical systems*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*articulate the fundamental concepts of edge computing*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*construct key components of edge computing architecture*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*recognize the strategy of using edge computing technology in internet of thing (IoT)*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*implement use cases in multi-access edge computing technology and develop services for it*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*adapt edge computing technology for digitalization of electrical system application*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Edge Computing	***9 Hour***
Edge Computing: Introduction - Basic characteristics and attributes - Scenario's and Use cases – Challenges -Cross value of edge computing- Edge vs Fog Computing - Collaboration of Edge Computing and Cloud Computing-Communication Models - Edge, Fog and machine-to-machine-Edge devices –Edge Analysis	
Unit-2 - Edge Computing Architectures	***9 Hour***
Introduction - Standard reference architecture - Edge computing Network - Development service framework -Deployment operation service framework (Smart services) - Full life cycle data service - Security service	
Unit-3 - Edge Computing in IoT	***9 Hour***
Mobile operation IoT edge - Key benefits - Unique requirements - Use cases - Device management – Security - Service enablement - Message prioritization - Data replication - Cloud enablement - Standards for self-organization, self-configuration, self-discovery - IoT using edge computing, Use cases & Technical Analytics.	
Unit-4 - Multiaccess Edge Computing (MEC)	***9 Hour***
Mobile operation IoT edge - Key benefits - Unique requirements - Use cases - Device management – Security - Service enablement - Message prioritization - Data replication - Cloud enablement - Standards for self-organization, self-configuration, self-discovery - IoT using edge computing, Use cases & Technical Analytics.	
Unit-5 - Applications of Edge Computing in Electrical Systems	***9 Hour***
Smart grids enabled by edge computing – Power Distribution Monitor Systems - Micro-Grid Systems by edge computing - Advanced Metering Systems - Integration of Edge Computing with IoT Enabled Smart Grid - Architecture, Applications – Energy management for edge computing- Edge computing for renewable energy systems-Challenges and Open Issues.	

Learning Resources	1. *Ajit Singh, "Edge Computing: Simply in Depth", third edition, 2022.* 2. *Jie Cao, Quan Zhang, Weisong Shi "Edge Computing: A Primer, Springer Briefs in Computer Science", Springer Cham, first edition, 2018.* 3. *Rajkumar Buyya, Satish Narayana Srirama, "Fog and Edge Computing: Principles and Paradigms, Wiley Series on Parallel and Distributed Computing", first edition, 2019.* 4. *Dario Sabella, Alex Reznik, Rui Frazao, "Multi-Access Edge Computing in Action", CRC Press, first edition, 2022.*	5. *Perry Lea, "IoT and Edge Computing for Architects: Implementing edge and IoT systems from sensors to clouds with communication systems, analytics, and security", Packt Publishing Limited, second edition, 2020.* 6. *J. Taheri and S. Deng, "Edge Computing: Models, Technologies and Applications". The Institution of Engineering and Technology (IET), 2020.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Arish, PwC AC Bangalore*	1. *Dr. K. Vijayakumar, IIITDM Kancheepuram*	1. *Dr. C. Naveen, SRMIST*
2. *Mr. S.S. Biswas, Department of Atomic Energy, Bhavini Kalpakkam*	2. *Dr. D.V. Shivakrishna Rao, NIT Trichy*	2. *Dr. V. Pradeep, SRMIST*

Course Code	21EEE424T	Course Name	FUNDAMENTALS OF BLOCK CHAIN TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*interpret the basic concepts of block chain technology*
CLR-2:	*assess the standards and protocols of block chain*
CLR-3:	*evaluate the risks of using block chain technology*
CLR-4:	*examine the various platforms for block chain development*
CLR-5:	*analyze the various enterprise use cases of block chain*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*acquire the basic concepts of block chain*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*enumerate the basic standards and protocols of block chain*	*2*	-	-	-	*1*	-	-	*2*	-	-	-	-	-	-	-
CO-3:	*articulate the security threats involved in block chain development*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*analyze the various platforms for block chain development*	*2*	-	*2*	-	*1*	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*develop a minimalist block chain enterprises application*	*2*	-	*2*	-	*1*	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - A Survey of Blockchain	***9 Hour***
Introduction to blockchain, History of bit coin and blockchain, Blockchain vs. traditional database, IoT based blockchain, Digital Ledger Technology (DLT), Peer-to-Peer (P2P) Network, Centralized systems, Decentralized systems, Layers of blockchain, Benefits and uses of blockchain, Public Blockchain, Private Blockchain, Bitcoin Crypto currencies.	
Unit-2 - Protocols, Standards and Key Concepts of Blockchain	***9 Hour***
Elements of blockchain technology, types of blockchain, important features of blockchain protocol, different blockchain protocols, Blockchain network architecture, blockchain pillars – Immutability, Decentralized, Enhanced security, Transparency, Faster settlement, Consensus mechanisms – proof of work, proof of stake, Tokenization, fundamental properties of tokens, Smart Contracts, blockchain standards.	
Unit-3 – Blockchain Security and Threats	***9 Hour***
Blockchain security basics- Confidentiality, Integrity, and Availability, blockchain best practices – High level, software development and wallet best practices, blockchain security audits, Blockchain Security Assumptions, Blockchain Cryptography, Hashing, Certificate Standards and Management, Membership/Permissioning, Two-Factor Authentication, Blockchain Risks- Risk Assessment, Risk Mitigation, Blockchain threat Landscape	
Unit-4 – Blockchain Development	***9 Hour***
Blockchain programming languages, Most Common Development Languages, Blockchain Platforms and Development Languages, Ethereum Development, Hyper ledger Development, R3 Corda Development, Quorum Development, Blockchain Performance- Permission or Permission less Performance, Performance Testing, Ethereum Testing Tools	
Unit-5 – Blockchain Enterprise Cases	***9 Hour***
Merits and Technical merits of Blockchain, Business Merits of Blockchain, Common Elements of Blockchain Adoption, Blockchain in Financial Sector, Government sector, Healthcare sector and other potential sectors	

Learning Resources	1. *Holbrook J, "Architecting enterprise blockchain solutions", John Wiley & Sons, first edition, 2020.* 2. *E. Golden Julie, J. Jesu Vedha Nayahi, Noor Zaman Jhanjhi, "Blockchain Technology* 3. *Fundamentals, Applications, and Case Studies", CRC Press, first edition, 2020.*	4. *Raj, Koshik. "Foundations of blockchain: the pathway to cryptocurrencies and decentralized blockchain applications", Packt Publishing Ltd, first edition, 2019.* 5. *Thompson, Josh, "Blockchain: the blockchain for beginnings, guild to blockchain technology and blockchain programming", Create Space Independent Publishing Platform, 2017.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	*30%*	-	*30%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*10%*	-	*10%*	-	*10%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Murali Krishnan, Edutech Pvt. Ltd.*	1. *Dr. D. Devaraj, Kalasalingam Academy of Research and Education*	1. *Dr. J. Preetha Roselyn, SRMIST*
2. *Mr. Subhra S Sarkar, Planys Technologies.*	2. *Dr. P. Varalakshmi, MIT Campus*	2. *Ms. C. Nithya, SRMIST*

Course Code	21EEE425P	Course Name	INDUSTRIAL IOT AND AUTOMATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							1	0	4	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*impart knowledge on industrial IoT and automation*
CLR-2:	*experiment IoT by addresses, Arduino and raspberry Pi*
CLR-3:	*design and build an automated system using SCADA, PLC, DCS*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*gain knowledge in industrial IoT and automation concepts*	*3*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
CO-2:	*design and develop real time projects using Arduino and raspberry Pi for industrial applications*	*3*	*3*	*3*	*3*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
CO-3:	*develop and implement SCADA, PLC, DCS based real time applications*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*2*	*3*	*3*	*1*

Unit-1 - Introduction to IIoT and Automation ***15 Hour***

Architecture of IIoT, IoT node – IoT enabling technologies – Levels of deployment – Challenges of IIOT- Domain specific IoTs – SDN and NFV for IoT – ISO/OSI model – MAC address and IP address -Overview of TCP/IP and UDP - DNS – Classes of IP addresses – Static and dynamic addressing - IPV4 – IPV6 and 6LoPAN Automation overview, Requirement of automation systems, Architecture of Industrial Automation system, Introduction of PLC and supervisory control and data acquisition (SCADA). Industrial bus systems: modbus and profibus. Role of computers in measurement and control. Programmable logic controllers (PLC), Analog digital input and output modules, Distributed Control System (DCS) integration with PLC and Computers, Basic construction, and configuration of robot, Pick and place robot, Welding robot. Internet of things for plant automation and overview of Industry 4.0.

Unit-2 - Lab Practices and Project Design ***60 Hour***

Lab Practices:

- *Experiments on Smart Irrigation System and Pedestrian detection for real time monitoring with IoT*
- *Experiments using PLC and SCADA*
- *Experiments using DCS and robots*

Project Design:

The students should work as a team of not more than 3 to develop a real time Project which involve:

- *Designing, developing, coding, demonstrating, and implementing Industrial IoT projects.*
- *Demonstrating competence in applying engineering design considering multiple realistic constraints for automation projects (e.g., economic, environmental, sustainability, manufacturability, ethical, health and safety, social and political issues)*
- *Exhibiting mastery in technical writing, presentation skills and in preparing a formatted report on the project.*
- *Managing and working as a team in completing the project within the given time frame adhering to standards.*

Learning Resources	1. *Mahmood, Zaigham, "The Internet of Things in the Industrial Sector", Springer, first edition, 2019.* 2. *Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat, "Industrial Internet of Things: Cyber manufacturing System", Springer Publication, first edition, 2017.* 3. *Ismail Butun, "Industrial IoT Challenges, Design Principles, Applications, and Security", springer, first edition, 2020.*	4. *Arshdeep Bahga and Vijay Madisetti, "Internet of Things A Hands-on Approach", Universities Press, 2015.* 5. *Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", A press, 2016.* 6. *Vikalp Joshi Manoj Adhikari Raju Manoj Rajesh Singh Anita Gehlot, "Industrial Automation", BPB Publications, first edition, 2019.* 7. *Frank Lamb, "Industrial Automation: Hands-On", McGraw-Hill Education, first edition, 2013.* 8. *Mike Wilson, Implementation of Robot Systems, Elsevier, first edition, 2014.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		Formative CLA-1 Average of unit test (20%)		*Project Based Learning CLA-2 (60%)*		*Report and Viva Voce (20%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	-	*10%*	-	*30%*	-	-
Level 2	*Understand*	*30%*	-	-	*10%*	-	*30%*	-	-
Level 3	*Apply*	*20%*	-	-	*20%*	-	*20%*	-	-
Level 4	*Analyze*	*20%*	-	-	*20%*	-	*20%*	-	-
Level 5	*Evaluate*	-	-	-	*20%*	-	-	-	-
Level 6	*Create*	-	-	-	*20%*	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*		-	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Gibin Chacko George, Advanced Micro Devices*	1. *Dr. A. R. Jac Fredo, IIT Bhubaneswar*	1. *Dr. R. Femi, SRMIST*
2. *Mr. Vineeth Kartha, Mathworks*	2. *Dr. A. Amalin Prince, BITS Pilani*	2. *Dr. R. Narayanamoorthi, SRMIST*

Course Code	21EEE426T	Course Name	NONLINEAR CONTROL SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21EEC206J*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*gain knowledge on the need and concept of nonlinear system*
CLR-2:	*describe different strategies adopted in the stability analysis of nonlinear systems*
CLR-3:	*examine the frequency domain analysis of nonlinear systems*
CLR-4:	*identify and examine control problems using various control techniques*
CLR-5:	*develop knowledge and skills for designing different types of nonlinear controllers*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*illustrate the need of nonlinear system*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*apply the stability analysis strategies to the nonlinear systems*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*analyze the non-linear systems based on frequency domain*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*apply the linearization control methods to nonlinear systems*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*design non-linear controllers based on applications requirement*	*3*	*3*	*2*	-	*1*	-	-	-	-	-	-	-	*3*	*2*	-

Unit-1 - Non-Linear System Analysis	***9 Hour***
Introduction-Characteristics of nonlinear systems-non-linear models and non-linear phenomena-Second order systems-Classification of equilibrium points- Construction of phase portraits-Behavioral analysis of second order systems-Periodic orbits-Poincare Bendixson criterion- Bendixson Criterion-Existence and uniqueness of solutions-Lipschitz condition.	
Unit-2 - Stability of Nonlinear System	***9 Hour***
Stability of nonlinear systems-Lyapunov Stability-Stability of autonomous systems: Direct method, indirect method-Linear time invariant system analysis-The invariance principle-Instability Theorem-Comparison Functions-Existence of Lyapunov functions- Input to state stability.	
Unit-3 - Frequency Domain Analysis of Feedback System	***9 Hour***
Frequency domain analysis of feedback system- Circle criterion-Popov criterion- Describing function analysis	
Unit-4 - Feedback Linearization and Control	***9 Hour***
Control problems- Stabilization via linearization- Integral Control-Gain Scheduling-Stabilization and tracking problem Feedback Linearization-Input output linearization- Input state linearization- Full state feedback linearization- Stability-Robustness	
Unit-5 - Non-Linear Design Tools	***9 Hour***
Control design based on Lyapunov's direct method- Sliding mode control: Examples, stabilization, tracking, regulation via integral control-Back Stepping-High gain observers: Examples, stabilization, regulation via integral control- Case study on non-linear system design	

Learning Resources	
	1. *Hassan K. Khalil, "Nonlinear Systems", Pearson Education India, third edition, 2014.*
	2. *Shankar Sastry, "Nonlinear System Analysis, Stability and Control", Springer, 1999.*
	3. *Jean-Jacques E. Slotine and Weiping Li, "Applied Nonlinear Control", Prentice-Hall, NJ, 1991.*
	4. *M. Vidyasagar, "Nonlinear Systems Analysis", SIAM, second edition, 2002.*
	5. *H. J. Marquez, "Nonlinear Control Systems: Analysis and Design", John Wiley Interscience, first edition, 2003.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*10%*	-	*5%*	-	*10%*	-
Level 2	*Understand*	*10%*	-	*5%*	-	*10%*	-
Level 3	*Apply*	*40%*	-	*25%*	-	*40%*	-
Level 4	*Analyze*	*40%*	-	*25%*	-	*40%*	-
Level 5	*Evaluate*	-	-	*20%*	-	-	-
Level 6	*Create*	-	-	*20%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Anuj Kumar, Bombardier, Transportation, Ahmedabad	*1. Dr. Meenakshi, CEG, Anna University*	*1. Dr. N. Chellammal, SRMIST*
2. Mr. Hariharasudhan, Johnson Controls, Pune	*2. Dr. Venkatesan, NIOT, Chennai*	*2. Dr. R. Narayanamoorthi, SRMIST*

Course Code	21EEE427T	Course Name	DIGITAL CONTROL SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21EEC206J*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the fundamental of digital control systems and Z-transforms*
CLR-2:	*acquire the modelling of discrete time system*
CLR-3:	*apply the concept of stability test in discrete domain*
CLR-4:	*outline the concepts of state space model, controllability, and observability*
CLR-5:	*gain knowledge on the design of discrete controller and compensators*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*gain knowledge on sampling and Z transform technique*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*understand the digital modeling of practical systems*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*identify the stability of open loop and closed loop discrete-time systems*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*illustrate modelling and state variable analysis*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*design and analyze digital controllers and compensator*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Discrete Time Systems	***9 Hour***
Structure of digital control Systems, Discrete time model, Z transform properties, Inverse Z transform, Time and frequency response of discrete domain system. State space models of discrete systems, State space analysis, Solution of state equations, Sample and hold circuit, Mathematical Modeling of sample and hold circuit. Sampling theorem, ZOH equivalent.	
Unit-2 - Modelling of Digital Control Systems	***9 Hour***
Basic conversion model, effect of sampler in cascaded system, transfer function model for electrical and mechanical system, open loop system with digital filter, system with transport lag, state space model for closed loop system, Analog disturbance in digital systems.	
Unit-3 - Stability of Digital Control Systems	***9 Hour***
Stability of discrete state space models, Bilinear transformation, Stability analysis by Routh Hurwitz criterion and Jury's stability test, Stability analysis by time and frequency response plot, Design of digital control system with dead beat response. Practical issues with dead beat response design.	
Unit-4 - State Variable Analysis for Digital Control Systems	***9 Hour***
State space models of discrete systems, State space analysis. Solution of the Discrete-Time State Equation using Z transform, reachability, Controllability and Observability, Reconstructability and observability analysis. Effect of pole zero cancellation on the controllability and observability, State-space realization.	
Unit-5 - Controlled Design of Digital Control Systems	***9 Hour***
Introduction, Control system specifications, compensation – Lag, Lead, Lag lead compensator design using bode plot, Design of Discrete PID Controller, Design of discrete state feedback controller. Design of set point tracker. Design of Discrete Observer for LTI System. Sampled data control systems with deadbeat response.	

Learning Resources	1. *Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall, fifth edition, 2017.* 2. *M. Gopal, "Digital Control and State Variable Methods", McGraw Hill Education, fourth edition, 2017.* 3. *Charles Phillips, H. Nagle, Aranya Chakrabortty, "Digital control system analysis and design", Pearson Prentice Hall, fourth edition, 2014.*	4. *M. Sami Fadali, Antonio Visioli, "Digital Control Engineering Analysis and Design", Academic Press is an imprint of Elsevier, second edition, 2013.* 5. *Richard C.Dorf, Robert H.Bishop," Modern control system theory", Pearson Education Ltd, thirteenth edition, 2016.* 6. *Online course material: Plat form- NPTEL, Author – Dr. Indrani Kar, Prof. S. Majhi, IIT Guwahati, Web link: https://nptel.ac.in/courses/108103008*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. M. Sendhil, BHEL, Trichy*	1. *Dr. A. Venkatesan, NIT Puducherry, Karaikal*	1. *Dr. A Sureshkumar, SRMIST*
2. *Mr. R. Kalidoss, TANGEDCO, Trichy*	2. *Dr. G. Lakshmi Sutha, NIT Puducherry, Karaikal*	2. *Dr. R. Narayanamoorthi, SRMIST*

Course Code	21EEE428T	Course Name	INDUSTRIAL ROBOTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*familiarize with the concepts and terminologies of industrial robotics system*
CLR-2:	*impart knowledge on peripheral devices used in robotics*
CLR-3:	*provide essential knowledge on the kinematics of manipulator and its control methods*
CLR-4:	*learning robot programming techniques required for industrial robotics*
CLR-5:	*conduct a case study on recent robot applications*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*comprehend the basics of industrial robotics technology*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*select suitable sensors and actuators for robotic application*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*apply logic for selection of robotic sub systems*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*develop a program using basic programming constructs for various robot system*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*create a process plan for a given robotic application*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Introduction to Industrial Robotics ***9 Hour***

Introduction to robotics-History, growth; Laws of Robotics, degrees of freedom of planar and spatial manipulator, Robot classifications, work envelope, Internal and External Grippers; Selection and Design Considerations, resolution, accuracy and repeatability of robot, Robot applications- Manufacturing industry, defense, rehabilitation, medical etc.

Unit-2 - Sensors and Actuators for Robotics ***9 Hour***

Introduction to sensors, Requirements of a sensor, Principle, Characteristics and applications, sensor types-Touch, Potentiometer, Encoder, Position sensors - Piezo Electric Sensor, Range Meters, Resolvers, Force, Range and proximity. Wrist Sensors, Camera, Applications- Inspection, Identification, Actuators and types, DC motors, BLDC, stepper and servo motors. Case study on industrial robotics Sensors.

Unit-3 - Robot Kinematics ***9 Hour***

Robot kinematics – Basics of direct and inverse kinematics, Direct Kinematic Model – Mechanical structure and notations – Description of links and joints, Kinematic modeling of manipulator, Robot trajectories, 2D and 3D, Transformation-Scaling, Rotation, Translation Homogeneous transformation. Denavit-Hartenberg Notation – Kinematic Relationship between adjacent links, Manipulator Transformation Matrix, D-H algorithm. Control of robot manipulators – Point to point, Continuous Path Control.

Unit-4 - Robot Programming ***9 Hour***

Industrial Robot Programming- Introduction, Robot Programming Techniques-Lead-Through, Walk-Through Programming, Overview of Robot Programming Languages, VAL Programming-Motion Commands, Sensor Commands, End Effector commands and simple Programs. simple Programs Types of Robot Languages: VAL, RAIL, AML, Python, ROS, Case study: Role of AI&ML algorithms in industrial robotics

Unit-5 - Case Studies and Applications ***9 Hour***

Case studies: Industrial application of various configurations of robots Applications of industrial robots: Manufacturing applications, Material handling applications (Machine loading and unloading, Material transfer, Palletizing, Welding) Cleanroom robot

Learning Resources	1. *Mikell P. Groover, Mitchell Weiss, Roger Nagel, Nicholas G. Odrey, "Industrial Robotics: Technology, Programming, and Applications India", McGraw-Hill, first edition, 2012.* 2. *Gupta, A.K.., Westcott, Jean Riescher., Arora, S.K., "Industrial Automation and Robotics: An Introduction. India": Mercury Learning & Information, first edition, 2016.*	3. *Hegde, Ganesh S, "A Textbook of Industrial Robotics, India", Laxmi Publications, first edition, 2006.* 4. *Ramachandran Nagarajan, "Introduction to Industrial Robotics", Pearson Education India, first edition, 2016.* 5. *Miller, R. K., "Industrial Robot Handbook", Springer US, first edition, 2013.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*30%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*30%*	-	*20%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Balaji Kuppusamy, Mechatriks Industrial Services Pvt Ltd (OPC)*	1. *Dr. S. Senthil Kumar, NIT, Trichy*	1. *Dr. C. Balaji, SRMIST*
2. *Mr. Saikumar Bairabathina, Valeo India Private Limited*	2. *Dr. E Paul Brinard, IIIT, Chittoor*	2. *Dr. A. Dominic Savio, SRMIST*

Course Code	21EEE429T	Course Name	REAL TIME EMBEDDED SYSTEM	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*enrich the concepts of embedded C programming*
CLR-2:	*understand the architecture and programming of PIC microcontroller*
CLR-3:	*understand the architecture and programming of ARM processor*
CLR-4:	*impart the knowledge on the communication protocols*
CLR-5:	*impart the knowledge on the real time operating systems*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the fundamentals of embedded system C programming*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*develop the program using PIC microcontroller for embedded system applications*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*develop the program using ARM microcontroller for embedded system applications*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*analyze the potential importance and concepts of various communication protocols*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*explore the basics of real time operating systems*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Embedded C Programming	***9 Hour***
Introduction to Embedded C, Keywords, Data type and its memory representation, Arrays and strings, Types of Operators, Decision making with if, else, While, Do- While statement Switch, GOTO, FOR statement, Functions in Embedded C, Pointers, Command line Arguments, Compiler in Practical Program Writing using Embedded C	
Unit-2 - PIC Microcontroller and Programming	***9 Hour***
Microcontrollers Classifications and Embedded System Applications, Overview of the PIC18 Family, PIC18 PIN connection, PIC18 Configuration Registers, PIC18 File Register and access Bank, Architecture of PIC18, Instructions Sets of PIC18, PIC18 I/O Port Programming.	
Unit-3 - ARM Processor	***9 Hour***
ARM Processor Fundamentals, ARM organization, ARM Processor families, NuvoTon Cortex M0 (Nu-LB-NUC140) Architecture, Data Process instruction, Branch and Load instruction, Memory management, Cache memory.	
Unit-4 - Communication Protocol	***9 Hour***
Serial Bus communication protocols, RS232 standard and Characteristics, Overview of Serial Peripheral Interface (SPI), Introduction to Inter Integrated Circuits (I2C), I2C Data Transfer Protocol, ZigBee Network Overview, ZigBee Protocol, Universal Serial Bus (USB)	
Unit-5 - Real Time Operating Systems	***9 Hour***
Real Time Operating Systems: Tasks and Task states, Tasks and Data share, Shared data problems, Re-entrancy, Re-entrancy Rules, Semaphores and Shared data, RTOS Semaphores, Initializing semaphores, Re-entrancy and Semaphores, Multiple semaphores. Message Queues, Mailboxes and Pipes	

Learning Resources	1. *Muhammad Ali Mazidi, Sarmad Naimi, Sepehr Naimi, "AVR Microcontroller and Embedded Systems: Using Assembly and C", Pearson Education India; first edition, 2013.* 2. *John Peatman, "Design with PIC Microcontrollers", Pearson Education Asia, first edition, 2002.*	3. *Steve Furber, "ARM System-on-chip architecture", Pearson Education, 2014.* 4. *Louis E. Frenzel, "Handbook of Serial Communications Interfaces: A Comprehensive Compendium of Serial Digital Input/Output (I/O) Standards", Newnes first edition, 2015.* 5. *David E.Simon, "An Embedded Software Primer", Pearson Education, first edition, 2002.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*15%*	*-*	*30%*	*-*
Level 2	*Understand*	*20%*	*-*	*15%*	*-*	*30%*	*-*
Level 3	*Apply*	*30%*	*-*	*20%*	*-*	*20%*	*-*
Level 4	*Analyze*	*30%*	*-*	*20%*	*-*	*20%*	*-*
Level 5	*Evaluate*	*-*	*-*	*15%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*15%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Ashwin, Qualcomm*	1. *Dr. R. Ramesh, CEG, Anna University*	1. *Dr. R. Narayanamoorthi, SRMIST*
2. *Mr. Vvss Anjaneya Gupta, KPIT technologies*	2. *Dr. P. Vanaja Ranjan, CEG, Anna University*	2. *Dr. D. Suchitra, SRMIST*

Course Code	21EEE430T	Course Name	GOVERNANCE IN INFRASTRUCTURE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*recognize the perspectives for infrastructure development through policies and regulation*
CLR-2:	*outline the deterioration modeling, management, and commissioning*
CLR-3:	*elucidate the appropriate infrastructure for better governance*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*comprehend the concept of urban and rural infrastructure and its framework*	*2*	-	-	-	-	-	*3*	-	-	-	-	*2*	-	-	*2*
CO-2:	*identify the issues related to infrastructure projects*	*2*	-	-	-	-	-	*3*	-	-	-	-	*2*	-	-	*2*
CO-3:	*infer the infrastructure development towards sustainability*	*2*	-	-	-	-	-	*3*	-	-	-	-	*2*	-	-	*2*

Unit-1 - Introduction	***9 Hour***
Overview, Classification - Urban Infrastructure, Rural Infrastructure, Roadway Infrastructure, Building Infrastructure, Water Infrastructure, Telecommunications Infrastructure, Electricity Power Generation, Transmission and Distribution Infrastructure, Importance of infrastructure, Goals for infrastructure management, Role of Infrastructure Managers, Organizations for infrastructure management.	
Unit-2 - Infrastructure Development	***9 Hour***
Development: Emerging issues. Inter-relationship between the infrastructure and economic and social development, typical problems in infrastructure development: designing, funding, human resources, delivery of infrastructure, Public policy and governmental involvement in infrastructural development – Role of central, state, local governments, private investment. International experience in development of major infrastructure.	
Unit-3 - Deterioration Modeling	***9 Hour***
Simple Decision Making and Forecasting from Condition Assessment, Regression Based Deterioration Modeling, Markov Probabilistic Deterioration Modeling, Artificial Neural Networks for Deterioration Modeling, Failure Models and Survival Probability, Fault Tree Analysis, Linear Optimization for Infrastructure Management, Integer Optimization, Non-Linear Optimization, Combining Linear Optimization with Markov Deterioration Models, Short Run Cost Functions for Infrastructure, Demand Fluctuation with Low, Medium and High Usage Situations, Budgets and Revenues from Usage, Life Cycle Costs, Taxes and Finance of Infrastructure, Long Run Investment Decisions and Cost Functions, Decision Analysis and Monte Carlo Simulation for Long Run Investment Decisions.	
Unit-4 - Management and Commissioning	***9 Hour***
Infrastructure Interdependencies and Resiliency, Infrastructure Security, Preparing for Emergencies, Reacting to Emergencies, Contract Management, Workflow Management, Testing New Facilities, Documenting New Facilities, Integrating New Facilities into Infrastructure Management.	
Unit-5 - Infrastructure and Sustainability	***9 Hour***
in infrastructure development, Land, forest and other environmental concerns, green growth, judicious use of natural resources, Low carbon technologies in transport and energy, Incorporation of SDGs in infrastructure policies.	

Learning Resources	1. *Donald Coffelt and Chris Hendrickson, "Fundamentals of Infrastructure Management", third edition, 2019.* 2. *P. Chandra, "Projects: Planning, analysis, selection, financing, implementation, and review", Tata McGraw-Hill, ninth edition, 2019.*	3. *Willie Tan, "Principles of project and infrastructure finance", Taylor and Francis, first edition, 2007.* 4. *Thomas J. Webster, "Managerial Economics: Theory and Practice", Academic press, 2003.* 5. *James Parkin and D. Sharma, "Infrastructure planning", Thomas Telford Limited, 1999.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*50%*	-	*50%*	-	*50%*	-
Level 2	*Understand*	*50%*	-	*50%*	-	*50%*	-
Level 3	*Apply*	-	-	-	-	-	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Bhaskarsahu, Schneider Electric Ltd.*	1. *Dr. K. S. Swarup, IIT Madras*	1. *Mr. M. Sadees, SRMIST*
2. *Mr. N. Saravanan, L & T, Chennai*	2. *Dr. M. Senthil Kumar, NIT Patna*	2. *Dr. R. Ramya, SRMIST*

Course Code	21EEE431T	Course Name	RESPONSIBLE CONSUMPTION AND PRODUCTION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*outline the basics of sustainable consumption and production framework*
CLR-2:	*discover the sustainable management and use of natural resources*
CLR-3:	*enrich the knowledge of global per capita food waste*
CLR-4:	*discover the importance of chemicals and waste management*
CLR-5:	*familiarize the concept of reducing, reusing and recycling waste*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*enumerate the policies, data sources, collections, computation, management, and assessment of sustainable consumption*	2	-	-	-	-	-	3	-	-	-	-	3	-	-	1
CO-2:	*explain the material extractions and utilization of resources*	2	-	-	-	-	-	3	-	-	-	-	3	-	-	1
CO-3:	*describe the indexes in food waste and the importance of waste food measurement*	2	-	-	-	-	-	3	-	1	-	-	3	-	-	1
CO-4:	*interpret the processes involved in the management of hazardous waste*	2	-	-	-	-	-	3	-	-	-	-	3	-	-	1
CO-5:	*examine the sustainable procurement plans, reports, and the process of material recycling*	2	-	-	-	-	-	3	-	-	-	-	3	-	-	1

Unit-1 - Sustainable Consumption and Production Framework	***9 Hour***
Goal definition and concepts - policy cycle – data source type and collection – methods of computation – validation and adjustments – quality management, - assurance and assessment.	
Unit-2 - Sustainable Management and Use of Natural Resources	***9 Hour***
Domestic material extraction – Trade of materials – data sources – accounting methods –guidelines for data compilation – Material outflows – emission to air – waste landfilled – emissions to water – dissipative use of products – material balance.	
Unit-3 - Halve Global Per Capita Food Waste	***9 Hour***
Global food loss - index – food loss by regions – food estimates - methodological challenges and limitations - benefits of waste food measurement – case studies.	
Unit-4 - Responsible Management of Chemicals and Waste	***9 Hour***
International agreements on hazardous waste – generation – e-waste –generation rate in different regions – estimation – environment treatment – disaggregation – opportunities and limitations	
Unit-5 - Substantially Reduce Waste Generation	***9 Hour***
National recycling rate - material recycled - material exported and imported - total waste generated by the type of waste - national recycling rate by type of waste - waste intensity - opportunities and limitations – Companies publishing sustainability reports - National sustainable procurement plans - Understanding of sustainable lifestyles - Monitoring sustainable tourism - Removing fossil fuel subsidies	

Learning Resources	1. *https://www.unep.org/explore-topics/sustainable-development-goals/why-do-sustainable-development-goals-matter/goal-12* 2. *Hamish Forbes (WRAP), Tom Quested (WRAP), Clementine O'Connor (United Nations Environment Programme), "UNEP Food Waste Index Report", first edition, 2021.*	3. *https://www.un.org/sustainabledevelopment/sustainable-consumption-production/* 4. *Martin J. Ossewaarde, "Introduction to Sustainable Development", SAGE Publications Pvt. Ltd, first edition.* 5. *Mishra, P K, J K Verma, "Managing Sustainable Development Concepts Issues and Challenges", Associated Publishing Company, first edition, 2019.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*35%*	*-*	*35%*	*-*	*35%*	*-*
Level 2	*Understand*	*35%*	*-*	*35%*	*-*	*35%*	*-*
Level 3	*Apply*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 4	*Analyze*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Vijayakumar Kesavan, Staqual Precision Private Limited*	1. *Dr. T. Logeswaran, Kongu Engineering College, Erode*	1. *Dr. A. Geetha, SRMIST*
2. *Mr. Francis Suresh Balan, CGS Green Sustainergy Pvt. Ltd*	2. *Dr. M. Durairasan, University College of Engineering, Thirukkuvalai*	2. *Dr. R. Ramya, SRMIST*

Course Code	21EEE432T	Course Name	SUSTAINABLE INDUSTRIAL REVOLUTION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*describe the various stages of the fourth industrial revolutions*
CLR-2:	*illustrate the development of industry 4.0 in various fields*
CLR-3:	*explore the energy use and CO_2 emission in industry 4.0 and the importance of leadership*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*acquire knowledge on the importance of industrial revolutions*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-	-	*2*
CO-2:	*recognize the various developments in industry 4.0*	*3*	-	-	-	-		-	-	*2*	-	-	-	-	-	*2*
CO-3:	*realize energy usage in industries and comprehend the importance of leadership*	*3*	-	-	-	-	-	*3*	-	-	-	-	-	-	-	*2*

Unit-1 - Introduction to Industrial Revolution	***9 Hour***
History of the industrial revolution, Stages of the Industrial revolution in brief, generalized model of the industrial revolution, Essence and key parameters of different industrial revolutions, Criteria for evaluating the consequences of the industrial revolution.	
Unit-2 - The Fourth Industrial Revolution	***9 Hour***
Industry 4.0 – Formation in various countries, Process, Effects of new technology, Comparative analysis of the formation of industry 4.0 in developed and developing countries, Augmented risk management process.	
Unit-3 - Evolution of Industry 4.0	***9 Hour***
Development of industry 4.0 with respect to the knowledge economy, development of Industry 4.0 in modern economic systems - mechanism of managing the process of formation, Institutional model, Scenarios of development of industry 4.0, Implementation of the optimal scenario for managing the development of Industry 4.0, The Ways of Innovation, The Role of the Government, Role of digital technologies in Sustainable Construction.	
Unit-4 - The Energy Perspective	***9 Hour***
Overview of Industry, Industry scenarios, Energy use and CO_2 emission in industry, Technologies for reducing direct CO_2 emissions, Policy implications, Trends in energy efficiency and CO_2 emissions - Iron and Steel, Chemicals and petrochemicals, Pulp and paper, Solar Electricity in the Real World, Strategy, Business Model and Architecture in Today's Automotive Industry.	
Unit-5 - The Future of NextGen Leadership to Drive Digital Era	***9 Hour***
The New Realities of Leadership, Identifying, Assessing, and Selecting NextGen Leaders, Development and Coaching of NextGen Leaders, Leading High-Performance NextGen Teams, Leadership 4.0—The Future of NextGen Leadership.	

Learning Resources	1. *Elena G. Popkova, Yulia V. Ragulina, Aleksei V. Bogoviz, "Industry 4.0: Industrial Revolution of the 21st Century, Studies in Systems, Decision and Control", vol 169, Springer, first edition.* 2. *Oke, A.E., Aigbavboa, C., Stephen, S.S., & Thwala, W.D, "Sustainable Construction in the Era of the Fourth Industrial Revolution", Routledge, first edition, 2021.* 3. *IEA, "Energy Technology Transitions for Industry: Strategies for the Next Industrial Revolution", OECD Publishing, Paris, 2009.*	4. *Emblemsvag, J., "Technological Development Necessary but not Sufficient. In: Reengineering Capitalism", Springer, 2016.* 5. *Emblemsvåg, J, "The Role of the Government. In: Reengineering Capitalism", Springer, 2016.* 6. *Bradford, T, "Solar Revolution: The Economic Transformation of the Global Energy Industry, United Kingdom", MIT Press, 2008.* 7. *Wedeniwski, S, "Strategy, Business Model and Architecture in Today's Automotive Industry. In: The Mobility Revolution in the Automotive Industry", Springer, 2015.* 8. *Bawany, S, "Transforming the Next Generation Leaders, Business", Expert Press, 2019.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*40%*	-	*40%*	-	*40%*	-
Level 2	*Understand*	*40%*	-	*40%*	-	*40%*	-
Level 3	*Apply*	*10%*	-	*10%*	-	*10%*	-
Level 4	*Analyze*	*10%*	-	*10%*	-	*10%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Bhaskarsahu, Schneider Electric Ltd.*	1. *Dr. K. S. Swarup, IIT Madras*	1. *Mr. D. Ravichandran, SRMIST*
2. *Mr. R. Paneerselvam, Retd S.E/south/TANGEDCO – GM, IHPC*	2. *Dr. M. Senthil Kumar, NIT Patna*	2. *Mr. P. Kanakaraj, SRMIST*

Course Code	21EEE433T	Course Name	IMPACT MEASUREMENT AND MANAGEMENT FOR THE SUSTAINABLE DEVELOPMENT GOALS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*recognize the impact on sustainable development goals*
CLR-2:	*impart knowledge on sustainable investments and frameworks*
CLR-3:	*articulate on the theory of managerial communication, social development and economic growth*
CLR-4:	*familiarize the project planning, management and evaluation techniques*
CLR-5:	*identify the resource management and critical perspectives on sustainable development*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the basic concepts, modelling and impact measurement of sustainable process*	*2*	-	-	-	-	-	*3*	-	-	-	-	*2*	-	-	*2*
CO-2:	*acquire knowledge on the sustainability reporting frameworks, impact measurement frameworks and methodologies*	*2*	-	-	-	-	-	*3*	-	-	-	-	*3*	-	-	*2*
CO-3:	*outline the scope of sustainable development and economic development*	*1*	-	-	-	-	-	*3*	-	-	-	-	*2*	-	-	*2*
CO-4:	*elucidate the importance and process of project planning, implementation, monitoring and evaluation*	*2*	-	-	-	-	-	*3*	-	*2*	-	-	*3*	-	-	*2*
CO-5:	*analyze the current challenges and thematic areas of science and engineering on sustainable development*	*2*	-	-	-	-	-	*3*	-	-	-	-	*2*	-	-	*2*

Unit-1 - Impact Measurement on Sustainable Development Goals ***9 Hour***

Overview of impact measurement - Determining most material and focus SDGs – Basic concepts of indicators - Selection of indicators - Ambitions and targets - Collecting data and calculating impact scores - Responsible business simulator - The quantitative approach to every strategic decision- Modelling and sustainable process in engineering -Visualizing and interpreting the results exploring opportunities for improvement - Threshold value and appreciation - Sustainable growth within the boundaries of social and environmental systems.

Unit-2 - Measuring and Managing the Impact of Sustainable Investments ***9 Hour***

Introduction - A dual-axes framing of impact management and measurement harmonization initiatives - Mapping of the impact management and measurement initiatives- Impact measurement principles and guidance – Sustainable engineering principle- Impact measurement frameworks and methodologies - Impact measurement standards, certifications and ratings - Role of developed countries in the sustainable development of developing countries - Demographic dynamics and sustainability- Integrated approach for resource protection and management.

Unit-3 - Management of Social Welfare and Non-Governmental Organizations ***9 Hour***

Scope of Sustainable development globalization and economic growth- Economic development: Economic inequalities- Income and growth.- Social development: Poverty-conceptual issues and measures- impact of poverty- the concept of social welfare and non -governmental organizations – NGOs: coordinating agencies, Funding agencies and schemes- Management of social welfare and non -Governmental organizations- Management strategies and planning for NGOs -Managerial communication, skill and development- Coordination of job interviews, group discussions and meetings in the organization

Unit-4 - Project Planning and Management ***9 Hour***

Project planning and management: Concept - importance and process - Participatory rural appraisal tools for community need analysis including problem tree analysis- Stakeholder analysis and SWOT analysis - Project direction for engineering applications, Coordination and risk management- Issues in project management for engineering application - Human resource & financial management.

Unit-5 - Resource Management and Implications on Sustainable Development	***9 Hour***
Implications for valuation - Risk assessment; integrated decision-making processes: Requirements of information - Information flow - Data analytics- Learning from historical data - Multicriteria and multi-level decisions - Impact of governance and policies - Current challenges and thematic areas of science and engineering - Needs of present and future generation – Road to achieving sustainable development goals.	

Learning Resources	1. *Ovasdi, J. M, "Management of Non-Governmental Organizations: towards a developed civil society", Macmillan, 2006.* 2. *Elliott, Jennifer, "An Introduction to Sustainable Development", Routledge, London, fourth edition, 2012.* 3. *Rogers, Peter. Kazi F, Jalal, and John A. Boyd, "An introduction to Sustainable Development", Routledge, first edition, 2012.*	4. *https://www.pwc.nl/en/onze-organisatie/corporate-sustainability/sustainable-develoment-goals/sdg-impact-measurement-in-six-steps.html.* 5. *Ghosh, A.S, "Project Management", Anmol Publishers, McGraw Hill, Pub. Co. Ltd, 1990.* 6. *https://www.sciencedirect.com/science/article/pii/S1462901119300802.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*35%*	*-*	*30%*	*-*	*35%*	*-*
Level 2	*Understand*	*35%*	*-*	*30%*	*-*	*35%*	*-*
Level 3	*Apply*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 4	*Analyze*	*10%*	*-*	*20%*	*-*	*10%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Francis Suresh Balan, CGS Green Sustainergy Pvt. Ltd., Chennai*	1. *Dr. T. Logeswaran, Kongu Engineering College, Erode*	1. *Dr. S. Usha, SRMIST*
2. *Mr. S. Saravanan, S&S Engineering, Chennai*	2. *Dr. M. Durairasan, University College of Engineering, Thirukkuvalai*	2. *Dr. R. Ramya, SRMIST*

Course Code	21EEE434T	Course Name	ENERGY CONSERVATION AND EFFICIENCY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*provide overview on impact of energy conservation and efficiency for sustainable development*
CLR-2:	*familiarize the scope of energy efficiency and conservation opportunities in various electrical utilities*
CLR-3:	*understand the need for various energy efficiency and conservation opportunities in thermal utilities*
CLR-4:	*explain the significance of energy efficiency and conservation opportunities in various mechanical and building utilities*
CLR-5:	*outline various economic performance indices concepts for energy management studies*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the importance of energy conservation and efficiency*	*3*	-	-	-	-	-	*3*	-	-	-	-	-	-	-	*2*
CO-2:	*illustrate the energy saving and conservation process involved in electrical utilities*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-3:	*apply various energy saving and conservation techniques in thermal utilities*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	*2*
CO-4:	*evaluate various energy saving and conservation techniques in mechanical and building utilities*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	*2*
CO-5:	*analyze the various economic performance indices applicable for energy management*	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-	*2*	*2*

Unit-1 - Basic Introduction on Energy Conservation and Efficiency	***9 Hour***
Basics on energy- Energy conservation importance and energy strategy for future – Global energy trends and scenarios-Energy Pricing-Basics on energy efficiency-Needs for energy managers- National schemes and policy on energy efficiency- Standards on energy efficiency.	
Unit-2 - Energy Efficiency in Electrical Utilities	***9 Hour***
Motor drives- Motor efficiency testing- Energy efficient motors-Motor speed control - Electrical Systems, Transformers loss reductions, parallel operations -Transmission and Distribution losses-Power Factor improvements- Demand Side management (DSM)-Load Management-Harmonics and its improvements.	
Unit-3 - Energy Efficiency in Thermal Utilities	***9 Hour***
Energy conservation opportunities in boilers –Stream system- Boilers -Cogeneration-Waste heat recovery- cooling towers- Turbines.	
Unit-4 - Energy Efficiency in Mechanical and Building Utilities	***9 Hour***
Energy conservation in Pumps, Fans (flow control), Blowers, Compressed Air Systems, Refrigeration and air conditioning systems – Renewable Energy / Energy Efficiency integration - Solar systems in buildings-Lighting efficiency- Energy efficient windows- ECBC and its salient features- bioclimatic building concepts – IoT integration in energy efficiency building.	
Unit-5 - Economic Performance Indices for Energy Management	***9 Hour***
Payback – Simple and Discounted, Net Present Value, Internal Rate of Return, Benefit to Cost Ratio, E/D ratio, Life cycle/ levelized cost. Financial evaluation of energy projects, evaluation of proposals, profitability index, life cycle costing approach, investment decision and uncertainty-Energy Efficiency data analytics.	

Learning Resources	1. *Wayne C. Turner, "Energy Management Handbook", The Fairmount Press, Inc, ninth edition, 2018.* 2. *Barney L. Capehart, Wayne C. Turner and William J. Kennedy, "Guide to Energy Management", The Fairmont Press Inc., seventh edition, 2012.*	3. *Wayne C Turner, "Energy Management Handbook", the Fairmount Press, 2006.* 4. *G. G. Rajan, "Optimizing Energy Efficiencies in Industry", Tata McGraw Hill, first edition, 2001.* 5. *Bureau of Energy Efficiency Study material for Energy Managers and Auditors Examination: Paper I to IV.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Vijay Raju, National Productivity Council, Chennai*	1. *Dr. M. Premalatha, NIT Trichy*	1. *Dr. C. Naveen, SRMIST*
2. *Dr. M. Vivekanandan, TryCAE industrial engineering Pvt Ltd, Trichy*	2. *Dr. K. Vijayakumar, IIITDM Kanchipuram*	2. *Dr. R. Sridhar, SRMIST*

Course Code	21EEE435T	Course Name	ENERGY AUDITING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*gain a basic understanding on needs of energy auditing*
CLR-2:	*recognize the feasibility, approaches, techniques of energy conservation and electrical utilities*
CLR-3:	*importance of economics in industries*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand integrated approaches to energy auditing*	*3*	-	-	-	-	*2*	-	-	-	-	-	-	-	-	*2*
CO-2:	*identify the needs, approaches and strategies of energy conservation and power factor improvement*	*3*	-	-	-	-	*2*	-	-	-	-	-	-	-	-	*2*
CO-3:	*gain knowledge on energy economics in industries*	*2*	-	-	-	-	*2*	-	*2*	-	*2*	-	-	-	-	*2*

Unit-1 - Introduction to Energy Classification	***9 Hour***
Energy classifications, Power, Past and Present scenario of World, Sectorial energy consumption-domestic, industrial and other sectors - energy needs of growing - economy, Energy intensity - long term energy scenario, energy pricing - energy conservation importance, energy-strategy for the future - Environmental aspects - associated with energy conservation.	
Unit-2 - Energy Auditing and Standard	***9 Hour***
Energy Auditing: Needs, Types, Role of Energy Managers, Needs of Energy Managers-Instruments for energy auditing--Introduction to energy policy-National energy policy in the last plan Periods Municipal & Agriculture DSM Initiatives Standards and Labelling Programme EEC initiatives in Other Sectors Overview of renewable energy policy and the Five Year Plan programme, Energy Policies success stories, failures-case study.	
Unit-3 - Energy Conservation	***9 Hour***
Energy conservation in industries-Energy tariffs and Energy Instrument-Energy Efficiency in Building-Savings opportunities in HVAC-Conservation opportunities, Fans Conservation opportunities blowers-importance of cooling towers-Energy saving opportunities in cooling towers-case study.	
Unit-4 - Lighting Control and Power Factor Improvement	***9 Hour***
Introduction to Electrical Systems, Electrical network types and classifications-HT supply, LT supply-Illumination – Lux, Lumens--Types of lighting, Efficacy - Lighting Case Study - Energy Efficient Lighting Controls - Types of Capacitors - Concept of Capacitors - Power Factor Improvement.	
Unit-5 - Energy Economics in Industries	***9 Hour***
Investment - need, appraisal and criteria, financial analysis techniques, Simple payback period. Return on investment.Net present value, internal rate of return, cash flows, Production, cumulative sum of differences (CUSUM), Case study on payback period, Case study on net present value, Case study on CUSUM.	

Learning Resources	
1. *Witte. L.C., P.S. Schmidt, D.R. Brown, "Industrial Energy Management and Utilisation", Hemisphere Publ, 1988.* 2. *Callaghn, P.W., "Design and Management for Energy Conservation", Pergamon Press, Oxford, 1981.*	3. *Energy Manager Training Manual (4 Volumes) available at www.energymanager training.com, a website administered by Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power, Government of India, 2004.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. R. Viswanathan, Power Grid corporation	*1. Dr. S. S. Dash, GCE KJR*	*1. Dr. V. Kalyanasundaram, SRMIST*
2. Mr. R. Ramar, NTPI, Neyveli	*2. Dr. A. Venkadesan, NIT Puducherry, Karaikkal*	*2. Dr. S. Vidyasagar, SRMIST*

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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