ESTD : 1946

2022

OBE & CBCS

CURRICULUM

UNDERGRADUATE PROGRAMME

Third Year

Department of Electrical & Electronics Engineering (2023 -2027)

THE NATIONAL INSTITUTE OF ENGINEERING

(An Autonomous Institute under Visvesvaraya Technology University, Belagavi)

Recognised by AICTE, New Delhi

Manandavadi Road, Mysuru - 570 008

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Department Vision

The department will be an internationally recognized centre of excellence imparting quality education in electrical engineering for the benefit of academia, industry, and society at large.

Department Mission

M1: Impart quality education in Electrical and Electronics Engineering through theory and its applications by dedicated and competent faculty.

M2: Nurture creative thinking and competence leading to innovation and technological growth in the overall ambit of Electrical Engineering

M3: Strengthen industry-institute interaction to inculcate best engineering practices for sustainable development of the society

Program Educational Objectives

PEO1: Graduates will be competitive and excel in Electrical industry and other organizations.

PEO2: Graduates will pursue higher education and will be competent in their chosen domain.

PEO3: Graduates will demonstrate leadership qualities with professional standards for sustainable development of society

Programme Outcomes

Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety and the cultural, societal and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
9. **Individual and teamwork:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Specific Outcomes

Our Electrical and Electronics Engineering graduates will have the ability to:

PSO1: Apply the knowledge of Basic Sciences, Electrical and Electronics Engineering and Computer Engineering to analyse, design and solve real world problems in the domain of Electrical Engineering.

PSO2: Use and apply state-of-the-art tools to solve problems in the field of Electrical Engineering.

PSO3: Be a team member and leader with awareness to professional engineering practice and capable of lifelong learning to serve society

TABLE OF SCHEME AND EXAMINATION FOR V SEMESTER (2022-26 Batch)

Sl. No	Type of Course	Course Code	Course Title	Teaching Department (TD)	Question Paper setting Board (PSB)	Teaching Hrs/Week				Examination				Credits
						L	T	P	S	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
1	HSMS	BEE501	Management and Entrepreneurship	EEE	EEE	3	0	0		3	50	50	100	**3**
2	IPCC	BEE502	Control Systems	EEE	EEE	2	2	2		3	50	50	100	**4**
3	IPCC	BEE503	Power System Analysis - I	EEE	EEE	3	0	2		3	50	50	100	**4**
4	PCC	BEE504	Embedded Systems	EEE	EEE	3	0	0		3	50	50	100	3
5	PCCL	BEEL505	Embedded Systems Lab	EEE	EEE	0	0	2		3	50	50	100	1
6	PEC	BEE515X	Professional Elective Course (Industry suggested course) - Group I	EEE	EEE	3	0	0		3	50	50	100	**3**
7	PROJ	BEE586	Minor Project	EEE	EEE	0	0	2		-	50	-	50	**1**
8	AEC	BRMEE557	Research Methodology and IPR	EEE	EEE	2	0	0		2	50	50	100	**2**
9	MC	BESK508	Environmental Studies	CE/ Che	CE	1	0	0		-	50	-	50	**1**
10	MC	BNSK559	National Service Scheme (NSS)	NSS Coordinator		0	0	2		_	100	_	100	**0**
		BPEK559	Physical Education (PE) (Sports & Athletics)	PED										
		BYOK559	Yoga	Yoga Teacher										
Total											**500**	**350**	**900**	**22**

Professional Elective Course – Group I			
BEE515A	Industrial Control and Automation (2-0-2-0)	BEE515D	Data Structures and Algorithms (3-0-0-0)
BEE515B	Biomedical Instrumentation (3-0-0-0)	BEE515E	Data Analytics & IoT (3-0-0-0)
BEE515C	Electrical Power Quality (3-0-0-0)	BEE515F	Design and Implementation of Switched Mode Power Converters (2-0-2-0)

Note:*Total Marks = CIE out of 100 marks scaled down to 50 marks + SEE out of 100 marks scaled down to 50 marks.*
Total Marks = CIE out of 100 marks, for courses with no SEE.

TABLE OF SCHEME AND EXAMINATION FOR VI SEMESTER (2022-26 Batch)

Sl. No	Type of Course	Course Code	Course Title	Teaching Department (TD)	Question Paper setting Board (PSB)	Teaching Hrs/Week				Examination				Credits
						L	T	P	S	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
1	IPCC	BEE601	Switchgear and Protection	EEE	EEE	3	0	2		3	50	50	100	**4**
2	PCC	BEE602	Power System Analysis – II	EEE	EEE	2	2	2		3	50	50	100	**4**
3	PCC	BEE603	Electric Vehicles	EEE	EEE	3	0	0		3	50	50	100	3
4	PCC	BEE604	Digital Signal Processing	EEE	EEE	3	0	0		3	50	50	100	**3**
5	PCCL	BEEL605	Digital Signal Processing Lab	EEE	EEE	0	0	2		3	50	50	100	**1**
6	PEC	BEE613X	Professional Elective Course - Group II	EEE	EEE	3	0	0		3	50	50	100	**3**
7	OEC	BEE654X	Open Elective Course - Group I	EEE	EEE	3	0	0		3	50	50	100	**3**
8	AEC/ SDC	BEE657X	Ability Enhancement Course (AEC)/ Skill Development Course V (SDC)	EEE	EEE	If the course is a Theory: 1	0	0		-	50	_	50	**1**
						OR								
						If the course is a Laboratory: 0	0	2		-				
9	MC	BNSK658	National Service Scheme (NSS)	NSS Coordinator		0	0	2		_	100	_	100	**0**
		BPEK658	Physical Education (PE) (Sports & Athletics)	PED										
		BYOK658	Yoga	Yoga Teacher										
Total											**500**	**400**	**900**	**22**

Professional Elective Course - Group II

BEE613A	Soft Computing Techniques (3-0-0-0)	BEE613D	Electrical Machine Design (3-0-0-0)
BEE613B	Introduction to Battery Management Systems (3-0-0-0)	BEE613E	Embedded Controllers for Power Converters (1-0-4-0)
BEE613C	Machine Learning (3-0-0-0)	BEE613F	Circular Economy and Sustainability for Electrical Engineers (3-0-0-0)

Open Elective Course - Group I (Offered by EEE to other Departments)

BEE654A	Open Elective – I: Sensors and Signal Conditioning (3-0-0-0)	BEE654D	Open Elective –IV: Optimization Techniques (3-0-0-0)
BEE654B	Open Elective –II: Introduction to Electric Vehicle Technology (3-0-0-0)	BEE654E	Industry suggested course -I: Industrial Automation (3-0-0-0)
BEE654C	Open Elective –III: Computer Control of Industrial Process (3-0-0-0)	BEE654F	Industry suggested course -II: Industry 4.0 (3-0-0-0)

Ability Enhancement Course / Skill Enhancement Course-V

BEEL657A	PCB Design and Fabrication (0-0-2-0)	BEE/L657D	Industry suggested course -I: Green Fuels & Environmental Technology (1-0-0-0)
BEEL657B	Energy Audit, Management and Conservation (1-0-0-0)	BEE/L657E	Industry suggested course -II: Object Oriented Programming with C++ (0-0-2-0)
BEEL657C	Design of Control Systems (0-0-2-0)		

B.E Electrical and Electronics Engineering

(2022-2026)

Syllabus – V Semester

Department of Electrical and Electronics Engineering

The National Institute of Engineering

Mysuru-570 008

Course Code: BEE501
Credits: 3
SEE: 50% Marks
SEE Hours: 3

Course Name: Management and Entrepreneurship
L: T:P:S - 3:0:0:0
CIE: 50% Marks
Max. Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To equip students with the basic understanding of management and to provide them an insight into the entrepreneurship development.

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Understand the development of management thought and Concept of Entrepreneurs.	Understand
CO2	Apply the concept of HRM, marketing management & financial management	Apply
CO3	Apply the project management tools and concepts of Quality and /Industrial management to manage various projects.	Apply

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Entrepreneurship		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Introduction, Management & Administration, Types of ownership and Organization structures.	3	Nil
1.2	Concept of Entrepreneur, kind of Entrepreneurs, Entrepreneurship development and Govt. support in India.	3	Nil
1.3	Role of Entrepreneurs in Economic Development.	2	Nil
Module – 2: Human Resource Management and Organizational Behaviour			
2.1	Functions of HRM, Recruitment and Selection, Interviewing Candidates.	2	Nil
2.2	Human Resource Development, Training and Development, Performance Appraisal and Employee Compensation.	3	Nil
2.3	Motivation, Content Theories: Maslow and Herzberg, Stress and Conflict, Management by Objectives, Job Enrichment, Job rotation.	3	Nil
Module – 3: Marketing Management and Financial Management			
3.1	Introduction to marketing management, 5 Ps of Marketing, product life cycle, market Strategy	4	Nil
3.2	Introduction to financial management, Types of Finance, Balance Sheet and Profit and Loss account statement, working capital, International Finance	4	Nil
Module – 4: Project Management			
4.1	Project/Program/Portfolio Management, Phases in Project life cycle.	3	Nil
4.2	Top Down and Bottoms up Estimation, WBS, Stake Holder Management.	3	Nil
4.3	Identification of new Ideas, Evaluation of Alternatives.	2	Nil
Module – 5: Quality Management and Industrial Management			
5.1	Introduction to quality management, Contribution of Quality Gurus- Edward Deming (PDCA cycle), Joseph Juran (Quality trilogy), Quality Tools.	4	Nil

5.2	Innovation in science, technology and industry: IOT, Big Data and Analytics. Lean and Six Sigma, 5S Techniques, Energy Management	4	Nil
	Total No. of Lecture Hours	40	
	Total No. of Tutorial Hours		Nil

Textbooks:

1. N. V. R. Naidu**, "Management and Entrepreneurship",** Dreamtech Press**,** 2019.

Reference Books:

1. Stephen P. Robbins, **"Organizational Behavior",** Pearson Education India, 2022.
2. Prasanna Chandra, **"Projects: Planning, Analysis, Selection, Financing, Implementation and Review**", Tata McGraw Hill Publications, New Delhi, 2019.
3. I.M. Pandey, **"Financial Management",** 9thEdition, Vikas publication, 2011.

Course Code: BEE502
Credits: 4
SEE: 50% Marks
SEE Hours: 3

Course Name: Control Systems
L: T:P:S - 2:2:2:0
CIE: 50% Marks
Max. Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To enable students to model physical systems using transfer functions 2. To train students in analyzing system stability through various time domain and frequency domain methods 3. To prepare students to design PID controllers for specified performance 4. To develop students' skills in MATLAB simulation and analysis of control systems

Course Outcomes:

On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Model physical systems and evaluate their transfer functions	Apply
CO2	Analyse transient performance of first and second order systems	Analyse
CO3	Investigate stability of LTI systems by time domain and frequency domain methods	Analyse
CO4	Simulate and analyse the stability of control systems using MATLAB	Analyse

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: System Modelling		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Introduction to control systems, Feedback and non-feedback systems	1	Nil
1.2	Effects of feedback	1	Nil
1.3	Mathematical modelling of Electrical Systems	2	1
1.4	Mathematical modelling of Mechanical Systems	1	1
Module – 2: System Representation			
2.1	Block diagram representation	2	1
2.2	Signal flow graphs, Mason's gain formula	2	1
2.3	DC and AC Servomotors (speed-torque characteristics and transfer function).	1	Nil
Module – 3: Time-domain Analysis			
3.1	Standard test signals	1	Nil
3.2	Time response of first and second order systems,	1	1
3.3	Time-domain specifications	2	1
3.4	Steady-state error and error constants	1	Nil
Module – 4: Stability Analysis			
4.1	Introduction to system stability	1	Nil
4.2	Routh-Hurwitz criterion	1	Nil
4.3	Construction of root locus plots	2	Nil
4.4	Assessment of relative stability using root locus plots. Effect of adding poles and zeros on root locus plots	1	2

Module – 5: Frequency-domain Analysis			
5.1	Introduction, Frequency Domain Specification, Correlation between time response and frequency response	1	Nil
5.2	Bode Plot and and assessment of relative stability	2	Nil
5.3	Nyquist Stability Criterion	1	Nil
5.4	Nyquist plot and assessment of relative stability	1	2
	Total No. of Lecture Hours	**25**	
	Total No. of Tutorial Hours		**10**

List of Experiments:

Sl. No.	**Experiment**	**Hands on/ Virtual**
1	Study the time response of first order systems and to correlate the studies with theoretical results	Hands on
2	Study the time response of second order systems and to correlate the studies with theoretical results	Hands on
3	Determine the frequency response of a first -order system and evaluation of frequency domain specifications	Hands on
4	Determine the frequency response of a second -order system and evaluation of frequency domain specifications	Hands on
5	Speed-Torque characteristics and measurement of transfer function parameters of an AC servo motor	Hands on
6	Speed-torque characteristics of a DC servo motor	Hands on
7	Study the performance characteristics of P, PI, PD, PID controllers	Hands on
8	Obtain the phase margin and gain margin for a given transfer function by drawing bode plot and verify the same using MATLAB	Hands on
9	Draw the root loci for a given transfer function and verification of breakaway point and imaginary axis crossover point using MATLAB	Hands on
10	Analyse the stability of a given control system using Nyquist plot	Hands on

Textbooks:

1. I. J. Nagarath & M. Gopal, **"Control Systems Engineering",** 2021, New Age International (P) Ltd.
2. Kuo B.C, **"Automatic Control Systems",** 2014, Prentice Hall Inc.

Reference Books:

1. Norman S. Nise, **"Control Systems Engineering",** 2014, Wiley Student edition.

Course Code: BEE503
Credits: 4
SEE: 50% Marks
SEE Hours: 3

Course Name: Power System Analysis - I
L: T:P:S - 3:0:2:0
CIE: 50% Marks
Max. Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To teach students to construct per-unit system models 2. To train students in analyzing symmetrical component networks 3. To prepare students to evaluate economic dispatch solutions 4. To develop students' ETAP simulation skills for fault analysis, performance evaluation and economic dispatch of power systems

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Model power system components under balanced and unbalanced system conditions.	Apply
CO2	Simulate and analyse power system networks for symmetrical and unsymmetrical faults.	Analyse
CO3	Describe economic operation of the power system and compute the optimum generation schedule	Apply
CO4	Simulate and evaluate the performance of transmission lines and synchronous generators using MATLAB/E-TAP software	Analyse

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Representation of Power System Components		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Introduction, Circuit models of Synchronous machines, Transformer, Transmission lines and loads	2	Nil
1.2	Per unit system, Single line diagram, per unit impedance and reactance diagrams of power system, advantages of per unit system	3	Nil
1.3	Numerical Problems	2	Nil
Module – 2: Analysis of Symmetrical Three-Phase Faults			
2.1	Transients in RL series circuits, Short-circuit current and reactances of synchronous machine on no-load	3	Nil
2.2	Internal voltage of loaded synchronous machine under transient conditions, Numerical Problems	3	Nil
2.3	Simulation exercise using Mi-Power / ETAP software.	2	Nil
Module – 3: Symmetrical Components			
3.1	Operator 'a', symmetrical components of unsymmetrical phasors, Synthesis of unsymmetrical phasors from their symmetrical components, Power in terms of symmetrical components	4	Nil
3.2	Sequence impedances and sequence networks, Sequence networks of unloaded generators, Sequence networks of power systems, Problems	4	Nil
Module – 4: Analysis of Unsymmetrical Faults			
4.1	Single line-to-ground fault, line-to-line fault and Double line-to-ground fault on	3	Nil

	an unloaded synchronous generator, Numerical problems		
4.2	Unsymmetrical faults on power systems: Single line-to-ground fault on a power system, Line-to-line fault on a power system, Double line-to-ground fault on a power system, Numerical Problems	3	Nil
4.3	Interpretation of the interconnected sequence networks, faults through impedance, Numerical Problems	2	Nil
4.4	Simulation exercise using Mi-Power / ETAP software	2	Nil
Module – 5: Economic Operation of Power Systems			
5.1	Introduction, Generator operating cost, Performance curves	1	Nil
5.2	Economic dispatch neglecting losses, Economic dispatch including generator limits (Neglecting losses), Numerical Problems	3	Nil
5.3	Derivation of transmission loss formula, Economic dispatch including losses, Numerical Problems	3	Nil
	Total No. of Lecture Hours	40	
	Total No. of Tutorial Hours		Nil

List of Experiments:

Sl. No.	Experiment	Hands on/ Virtual
1	Performance evaluation of salient pole synchronous machines by determining power angle characteristics using MATLAB.	Hands on
2	Performance evaluation of non-salient pole synchronous machines by determining power angle characteristics using MATLAB.	Hands on
3	Performance evaluation of short transmission lines using ABCD parameters using MATLAB.	Hands on
4	Computation of ABCD parameters of medium transmission lines using nominal π method performance evaluation using MATLAB.	Hands on
5	Computation of ABCD parameters of medium transmission lines using nominal T method performance evaluation using MATLAB.	Hands on
6	Illustration of Ferranti effect in long transmission line using MATLAB simulation.	Hands on
7	Simulation of symmetrical short circuit on a given Power System in ETAP platform, plotting the fault currents and computation of sub-transient currents at different locations.	Hands on
8	Simulation of unsymmetrical short circuits (LG, LL and LLG faults) on a given Power System in ETAP platform, plotting the fault currents and computation of sub-transient currents at different locations.	Hands on
9	Solve Economic Dispatch problem on thermal plants without considering generator limits and transmission losses and using MATLAB.	Hands on
10	Solve Economic Dispatch problem on thermal plants considering generator limits and transmission losses using MATLAB.	Hands on

Textbooks:

1. W. D. Stevenson, **"Elements of Power System Analysis",** 4th edition, McGraw-Hill.
2. I. J. Nagrath and D.P. Kothari, **"Modern Power System Analysis",** 3rd edition, TMH.

Reference Books:

1. Haadi Sadat, **"Power System Analysis",** TMH.
2. P.N.Reddy, **"Symmetrical Components and Short Circuit Studies",** Khanna Publishers

Course Code: BEE504
Credits: 3
L:T:P:S - 3:0:0:0
SEE Hours: 3 Hrs

Course Name: Embedded System
CIE: 50% Marks
SEE: 50% Marks
Max. Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To teach students ARM Cortex-M3 architecture fundamentals 2. To train students in embedded C programming techniques 3. To prepare students to interface various sensors and actuators 4. To develop students' ability to implement communication protocols

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Discuss fundamental concepts of Embedded Systems and ARM Processor	Understand
CO2	Interface switches, Buzzer, LCD, Keypad, Motors, and Sensors with ARM microcontroller.	Analyze
CO3	Write programs using Instruction Set of ARM Microcontrollers and Embedded C to perform the tasks.	Analyze
CO4	Implement and Demonstrate Mini Projects using ARM Microcontrollers	Analyze

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Embedded Systems and ARM Processor fundamentals:		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Introduction to Microprocessors, Microcontrollers and Embedded Systems, ARM Technology Overview and Design Philosophy	2	Nil
1.2	ARM Processor Families, ARM Processor Embedded System Hardware and Software, ARM Memory Mapping	2	Nil
1.3	ARM Processor Modes, ARM Registers Set, ARM Core Data Flow Model	2	Nil
1.4	Stack Operation, Pipeline-Characteristics, Exceptions, Interrupts and Vector Table.	2	Nil
Module – 2: ARM Processor Instruction Sets and Programming:			
2.1	Data Processing Instructions, Data Transfer Instructions	2	Nil
2.2	Control Flow Instructions, Conditional Execution	2	Nil
2.3	Introduction to THUMB, Differences between ARM and THUMB	1	Nil
2.4	Bit-Banding, General Structure of ARM Assembly Module and Assembler Directives	1	Nil
2.5	ARM ALP Example Programs	2	Nil
Module – 3: ARM Microcontroller Peripherals and Programming:			
3.1	GPIOs Configuration, Timers, SysTick Timers, Watch Dog Timers	2	Nil
3.2	NVIC Controller, PWMs, RTC, PLL	2	Nil
3.3	DAC, ADC	2	Nil
3.4	Embedded C Example Programs	2	Nil

Module – 4: ARM Microcontroller Communication Protocols and Programming			
4.1	UARTs and Wireless Communication Protocols	2	Nil
4.2	I2C, SPI Protocols	2	Nil
4.3	CAN Protocols all Communication Protocols with Specification, Configuration and Modules	2	Nil
4.4	Embedded C Example Programs	2	Nil
Module – 5: ARM Microcontroller Interfacing and Programming:			
5.1	Interfacing of: Switches, Buzzer, Seven Segment Display	2	Nil
5.2	LCD (4-bit, 8-bit Mode), Keypad (4*4)	2	Nil
5.3	DC Motor, Stepper Motor, Servo motor	2	Nil
5.4	Relay, Ultrasonic Sensor, Temperature, Humidity, Soil Moisture Sensor, PIR sensor	2	Nil
	Total No. of Lecture Hours	40	
	Total No. of Tutorial Hours		Nil

Textbooks:

1. Joseph Yiu**, "The Definitive Guide to ARM Cortex M3"**, 2nd Edition.
2. Andrew N Sloss, Dominic Symes, Chris Wright, "**ARM System Developer's Guide"**,
3. LPC17XX User Manual

Reference books:

1. Steve Furber, Addison Wesley, **"ARM System-On-Chip Architecture"**, Pearson Education, 2nd edition.
2. William Hohl, Christopher Hinds, **"ARM ASSEMBLY LANGUAGE Fundamentals and Techniques",** 2nd Edition, CRC Press, 2015.
3. **ARM Assembly Language an Introduction,** Gibson Second Edition, 2007.

Course Code: BEEL505 **Course Name: Embedded Systems Lab**
Credits: 1 **L: T:P:S - 0:0:2:0**
SEE: 50% Marks **CIE: 50% Marks**
SEE Hours: 1 **Max. Marks: 100**

Prerequisites if any	Nil
Learning objectives	1. To train students in ARM microcontroller programming 2. To develop students' skills in peripheral interfacing 3. To prepare students to debug embedded systems 4. To enable students to implement control algorithms

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Develop an assembly level language program for ARM CortexM3 based LPC17xx Microcontroller using Keil software tool.	Analyze
CO2	Design and implement Embedded System applications using Embedded C language for ARM CortexM3 based LPC17xx Microcontroller.	Analyze

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

List of Experiments:

Sl. No.	**Experiment**	**Hands on/ Virtual**
	PART A	
Develop and demonstrate the following operation with the help of a suitable program in ALP using ARM Cortex M3 Evaluation board and the required software tool		
1	Data transfer operations	Hands on
2	Arithmetic operations	Hands on
3	Logical operations	Hands on
4	Code Conversions	Hands on
	PART B	
1	Interface a simple Switch and display its status through Relay, Buzzer and LED.	Hands on
2	Display the Hex digits 0 to F on a 7-segment LED interface, with an appropriate delay in between.	Hands on
3	Interface a 4x4 keyboard and display the key code on an LCD.	Hands on
4	Interface DC Motors, Stepper Motor, and Servo Motor rotate clockwise, anticlockwise and in angle (45^o, 90^o, 180^o).	Hands on
5	Generate different delay using Timers and count external pulses using counters	Hands on
6	Generate an Interrupt process and demonstrate the use of an external interrupt to toggle an LED On/Off.	Hands on
7	Using the Internal PWM module of ARM controller generate PWM and vary its duty cycle to Speed Control of DC motor and to change the intensity of Light.	Hands on
8	Generate non-sinusoidal and sinusoidal waveforms with variable amplitude and frequency using internal DAC.	Hands on
9	Display output for given analog input using internal ADC. (Use of Analog Sensors like Ultrasonic Sensor, Temperature, Humidity, Soil Moisture Sensor, PIR sensor)	Hands on
10	Interface Bluetooth Module, GPS module, GSM module, RF module and RFID cards to send & receive Data using internal UARTs.	Hands on

Course Code: BEE586
Credits: 1
SEE: -
SEE Hours: -

Course Name: Minor Project
L: T:P:S - 0:0:2:0
CIE: 100% Marks
Max. Marks: 50

Prerequisites if any	Nil
Learning objectives	1. To guide students in identifying technical problems 2. To train students in project documentation 3. To develop students' prototyping skills 4. To prepare students for ethical engineering practice

Course Outcomes:

On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Identify the topic of relevance and carry out literature review inculcating ethical practice	Apply
CO2	Formulate the problem, identify the objectives and implement solution methodology	Create
CO3	Present and document the project work	Analyse

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Evaluation:

Project work need to be carried out in groups and the evaluation will be done individually using appropriate rubrics.

Course Code: BRMEE557
Credits: 2
SEE: 50% Marks
SEE Hours: 2

Course Name: Research Methodology & IPR
L: T:P:S - 2:0:0:0
CIE: 50% Marks
Max. Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To teach research methodology fundamentals, problem formulation to ethical reporting. 2. To explain intellectual property rights (IPR) frameworks and their application in innovation.

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Explain the basic framework of research process, research design and techniques	Understand
CO2	Apply the processes of quantitative data collection, analysis, interpretation, presentation and report writing	Apply
CO3	Understand the Intellectual Property Rights	Understand

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Overview of research		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Introduction to research, Objectives and motivations for research, Significance of research, Research Methods v/s Methodology, Types of research, Quantitative Research Methods, Variables, Conjecture, Hypothesis. Research Process, Steps in research process, Criteria of good Research	2	Nil
1.2	Importance of literature review in defining a problem - Survey of literature - Primary and secondary sources -Reviews, - web as a source - searching the web - Identifying gap areas from literature review.	2	Nil
1.3	Development of working hypothesis. Research problem-definition, selection and formulation of a research problem selection, criteria of a good research problem.	2	Nil
1.4	Introduction to research design, Characteristics of good research design, Developing a research plan, Department/program specific research problem discussions	2	Nil
Module – 2: Data collection, processing and analysis			
2.1	Sources of data, collection of data, Primary and secondary Data, Collection of Data through various methods.	2	Nil
2.2	Measurement and scaling, Sources of error in measurement. Modelling, Mathematical Models for research.	2	Nil
2.3	Report writing and ethics in research: Writing Research Report: Format and style. Layout of a Research Paper, Research proposal, Citation of references.	2	Nil
2.4	Reference Management Softwares (Zotero/Mendeley), Softwares for paper formatting (LaTeX/MS Office), Significance of ethical conduct in research, Ethical issues related to publishing, Plagiarism. Software for detection of Plagiarism, Impact factor of Journals	3	Nil
Module – 3: Intellectual Property Rights:			
3.1	Introduction to Intellectual Property (IP), different types of IPs and its importance in the present scenario	3	Nil
3.2	Patent Acts: Indian patent acts 1970. Design Act:	2	Nil
3.3	Industrial Design act 2000. Copyright acts: Copyright Act 1957, Trade Mark Act, 1999	3	Nil
	Total No. of Lecture Hours	25	
	Total No. of Tutorial Hours		Nil

Textbooks:

1. Kothari, C.R., **"Research Methodology",** New Age International second revised edition, 2014.
2. Debirag E. Bouchoux**, "Intellectual property",** Cengage learning, 2013.

Reference books:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., **"An Introduction to Research Methodology",** RBSA Publishers, 2002.
2. Sinha S.C. and Dhiman AK**, "Research Methodology",** Ess, Publications, 2002.
3. Chawla, Deepak &Sondhi, Neena, **"Research methodology: Concepts and Cases",** Vikas Publishing House Pvt. Ltd. Delhi, 2011.

Course Code: BESK508
Credits: 1
SEE: -
SEE Hours: -

Course Name: Environmental Studies
L: T:P:S - 1:0:0:0
CIE: 50% Marks
Max. Marks: 50

Prerequisites if any	Knowledge of Physics, Chemistry, and Biology along with concepts of Ecology and Environment at a Basic level
Learning objectives	1. To teach students environmental impact assessment 2. To train students in pollution control methods 3. To prepare students to comply with environmental regulations 4. To develop students' understanding of sustainability practices

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Illustrate the relationship between human life and environment from scientific perspective and analyse the importance of natural resources	Understand
CO2	Summarize the impact of pollution and describe the control measures and importance of various National environmental acts and regulatory bodies	Apply
CO3	Describe the global environmental issues, explain the concept of EIA and Global environmental summits, treaties and protocol	Apply

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1:		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Introduction and definition of Environment, Man-Environment interaction, Impact of man's activity on Environment	1	Nil
1.2	Ecology, Energy/nutrient flow, Ecological pyramids, Types of Food Chain, Food Web	1	Nil
1.3	Biogeochemical cycle – Carbon Cycle, Nitrogen Cycle, Sulphur cycle	2	Nil
Module – 2: Data collection, processing and analysis			
2.1	Pollutant and its classification, Introduction to Pollution, sources of pollution, Water, Air, Noise pollution, nuclear hazards (Sources, effects, remedial measures, standards)	2	Nil
2.2	Solid waste and E-waste management: causes, effects and control measures of urban and industrial wastes.	1	Nil
2.3	Environmental Laws and protection Acts: environment protection act, Air (prevention and control of pollution) Act, Water (prevention and control of pollution) Act, Wildlife protection act, Forest conservation Act)	2	Nil
2.4	Pollution Control Boards' roles and responsibilities (CPCB and KPCB)	1	Nil
Module – 3: Intellectual Property Rights:			
3.1	Global environmental issues- global warming, acid rain, ozone depletion (reasons, effects, control measures), carbon footprint and carbon trading	2	Nil
3.2	International environmental management standards (ISO14000), Global environmental summits, treaties and protocols (important summits), Introduction to Environmental Impact Assessment (EIA), Environmental Auditing	2	Nil
3.3	Sustainable environmental concepts: water conservation – rainwater harvesting, artificial recharging, watershed management, Waste to energy – solid waste to energy conversion.	1	Nil
	Total No. of Lecture Hours	15	
	Total No. of Tutorial Hours		Nil

Textbooks:

1. Benny Joseph "**Environmental Science and Engineering**.", Tata McGraw-Hill Publishing Company Limited

Reference books:

1. Gilbert M. Masters "**Introduction to Environmental Engineering and Science**." Prentice-Hall of India Pvt. Limited.
2. Edward J. Kormondy "**Concepts of Ecology**" Prentice-Hall of India Pvt. Limited. 3. P. D. Sarma. "Ecology and Environment" Rastogi Publications.

Online Resources:

1. Introduction to Environmental Engineering and Science by NPTEL https://youtu.be/LjFt7rlCU84
2. Environmental Impact Assessment (EIA) Part-1 by NPTEL https://youtu.be/_iLdyhgFv1U
3. EIA by NPTEL https://youtu.be/yO_d6-P-ZZk 4 EIS & EIA by NPTEL .https://youtu.be/ErU5DSUq3B0

Course Code: BEE515A
Credits: 3
SEE: 50% Marks
SEE Hours: 3

Course Name: Industrial Control and Automation
L: T:P:S - 2:0:2:0
CIE: 50% Marks
Max. Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To familiarise the operation of control circuit components 2. To develop fundamental programming skills using PLC 3. To provide engineering insight into the performance of various building blocks in automation through SCADA

Course Outcomes:

On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Explain the operation of control circuit components in industrial control	Understand
CO2	Apply the concept of ladder logic in PLC Programming for industrial control	Apply
CO3	Understand various building blocks SCADA and apply for automation	Apply
CO4	Conduct experiments on the laboratory prototypes and study different building blocks of industrial control and automation.	Apply

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Control Circuit Components		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	MCCB & MCB, Contactors, Relays, Timers	2	Nil
1.2	Limit switches, pressure switches, Fuses and fuse switch Modules	2	Nil
1.3	Thermostats, Solenoid Valves, control transformers, symbols for various components	2	Nil
Module – 2: Industrial Control Circuits			
2.1	Introduction, Skip Hoist Control, Control of Electrical Oven	2	Nil
2.2	Air Compressor and Conveyor System	2	Nil
2.3	**Programmable Logic Controllers:** The Programmable Logic Controller, Hardware, Internal architecture	2	Nil
2.4	Programming PLCs, Logical sensors and Logical actuators	2	Nil
2.5	Counters, ladder and functional block programming, program examples	2	Nil
Module – 3: Introduction to Automation			
3.1	Evolution of Automation systems, History of automation systems, SCADA systems, SCADA applications, Introduction to SCADA fundamentals, Building blocks of SCADA systems	2	Nil
3.2	Remote terminal unit, Intelligent Electronic devices, Data concentrators and merging units	2	Nil
3.3	SCADA communication systems, Master station, Small, medium, and large master stations	2	Nil
3.4	Global positioning systems (GPS), Master station performance, Classification of SCADA systems, Advantages of SCADA in power systems	2	Nil
3.5	SCADA implementation: A laboratory model	1	Nil
	Total No. of Lecture Hours	**25**	
	Total No. of Tutorial Hours		Nil

List of experiments:

Sl.No.	Experiment	Hands on/ Virtual
1	Study of basic pilot devices, field devices and control components.	Hands on
2	Operation and functionality of contactors.	Hands on
3	Operation and functionality of Thermal Overload Relay and MCCB.	Hands on
4	Study of Electronic Overload Relay- different starting / tripping classes	Hands on
5	Study of DOL starter for Induction Motor.	Hands on
6	Study of Y-Δ starter of Induction Motor.	Hands on
7	Automatic reversal of direction of Induction Motor.	Hands on
8	Building of control logic circuits.	Hands on
9	Implementation of logic gates using PLC: AND Logic & OR Logic	Hands on
10	Implementation of Timers and Counters	Hands on

Textbooks:

1. S. K. Bhattacharya, Brijnder Singh, ***"Control of Machines"***, 2nd edition, New Age International Publisher, 2006.
2. Hugh Jack, ***"Automating manufacturing systems with PLCs"***, Version 4.6
3. Mini S. Thomas, John D. McDonald, ***"Power System SCADA and Smart Grids"***, CRC Press

Reference Books:

1. W. Bolten, ***"Programming Logic Controllers"***, Elsevier Publication, Oxford UK.

Course Code: BEE515B
Credits: 3
SEE: 50% Marks
SEE Hours: 3

Course Name: Biomedical Instrumentation
L: T:P:S - 3:0:0:0
CIE: 50% Marks
Max. Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To familiarize students with biomedical signal origins (ECG, blood pressure) and measurement techniques. 2. To demonstrate medical imaging principles (X-ray, CT, MRI) and therapeutic device operation. 3. To provide insight into diagnostic lab equipment, safety standards, and telemedicine applications.

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Describe the physiology of the human body and origin of biomedical signals.	Understand
CO2	Explain the working of different diagnostic instruments, Clinical Lab Equipment's and different imaging modalities.	Understand
CO3	Emphasize the knowledge on Telemedicine and Patient safety.	Understand

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Fundamentals of Medical Instrumentation		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Anatomy, Physiology, Physiology systems of the body	2	Nil
1.2	Sources of bio-medical signals, Basics of medical instrumentation	4	Nil
1.3	Performance requirements, Origin of biomedical signals	2	Nil
Module – 2: Diagnostics and Monitoring			
2.1	General concepts, ECG, Measurement of pulse rate	3	Nil
2.2	Blood pressure measurement, Cardiac output measurement	2	Nil
2.3	Measurement of respiration rate, EEG, Oximeter.	3	Nil
Module – 3: Medical Image Processing: X-ray			
3.1	Basics of diagnostic radiology, Nature Production of X-ray	3	Nil
3.2	Computed tomography & system components.	2	Nil
3.3	**MRI**: Principles and Image reconstruction techniques.	2	Nil
Module – 4: Surgical and Therapeutic: Defibrillator			
4.1	Need and DC defibrillators, Lithotripters: First and Modern Lithotripter, Anesthesia: Anesthesia machine	3	Nil
4.2	Ventilators: Mechanics of respiration, artificial ventilation, ventilators, types of ventilators	3	Nil
4.3	**Drug Delivery systems:** Infusion pumps and components, Implantable infusion systems.	2	Nil
Module – 5: Clinical Lab Equipment			
5.1	Equipment's: Spectrophotometer, Spectrophotometer, Colorimeter, Blood gas analyzers – Acid-base balance	3	Nil
5.2	Ph, PCO2 pO2 measurement (Intra- arterial blood gas monitoring), Types of blood	2	Nil

	cell, Method of blood cell counting.		
5.3	**Telemedicine and patient safety:** Shock hazard, leakage current, safety code for medical devices, safety analyzers, Radiation safety, Regulations of medical device, Telemedicine.	4	Nil
	Total No. of Lecture Hours	40	
	Total No. of Tutorial Hours		Nil

Textbooks:

1. R S Khandpur, **"Handbook of Biomedical instrumentation",** 2nd Edn., TMH,

Reference Books:

1. Nandini K Jog, **"Electronics in medicine and biomedical Instrumentation",** PHI, New Delhi, 2013

Course Code: BEE515C **Course Name: Electrical Power Quality**
Credits: 3 **L:T:P – 3:0:0:0**
CIE: 50% Marks **SEE: 50% Marks**
SEE Hours: 3 **Total Marks: 100**

Prerequisites if any	Nil
Learning objectives	1. To teach power quality issue identification and evaluation methods. 2. To provide engineering insight into the mitigation techniques for voltage disturbances and harmonic distortion.

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Discuss the various power quality phenomenon.	Understand
CO2	Interpret and evaluate the voltage sags, interruptions and Transient over voltages.	Apply
CO3	Discuss the fundamentals of harmonics and mitigation techniques.	Understand

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Introduction to Power Quality		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Power quality concern, Categories and Characteristics of Power System Electromagnetic Phenomena.	4	Nil
1.2	power quality evaluation procedures, definition and cause of various power quality disturbances, CBEMA and ITI Curves	4	Nil
Module – 2: Voltage Sags and Interruptions			
2.1	Sources of sags and interruptions, estimating voltage sag performance	4	Nil
2.2	Fundamental principles of protection, Solutions at the End-User Level	4	Nil
Module – 3: Transients Over Voltages			
3.1	Sources of Transient Over voltages, Ferro-resonance phenomenon, Principles of Overvoltage Protection	4	Nil
3.2	Devices for Overvoltage Protection, Utility Capacitor-Switching Transients, Utility System Lightning Protection. Cable protection.	4	Nil
Module – 4: Fundamentals of Harmonics			
4.1	Harmonic Distortion, Voltage versus Current Distortion, Harmonics versus Transients	4	Nil
4.2	Harmonic Indices, Harmonic Sources from Commercial Loads and Industrial loads, Locating Harmonic Sources, System Response Characteristics, series and parallel resonance	4	Nil
Module – 5: Applied Harmonics			
5.1	Harmonic distortion evaluations, principles for controlling harmonics, harmonic studies	4	Nil
5.2	Modeling of harmonic source, devices for controlling harmonic distortion, harmonic filters.	4	Nil
	Total No. of Lecture Hours	**40**	
	Total No. of Tutorial Hours		**Nil**

Textbooks:

1. Dugan, Roger C, Santoso, Surya, McGranaghan, Mark F Beaty, "**Electric Power Quality**," H. Wayne McGraw-Hill professional publication 2003.

Reference Books:

1. Math H. J.Bollen, "**Understanding power quality problems voltage sags and interruptions**", IEEE Press, 2000.

Course Code: BEE515D **Course Name: Data Structures and Algorithms**
Credits: 3 **L:T:P – 3:0:0:0**
CIE: 50% Marks **SEE: 50% Marks**
SEE Hours: 3 **Total Marks: 100**

Prerequisites if any	Nil
Learning objectives	1. To develop proficiency in algorithm efficiency analysis. 2. To train students in implementing stacks, queues, trees, and graph algorithms.

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Use different types of data structures, operations and algorithms	Understand
CO2	Apply searching and sorting operations on files	Apply
CO3	Use stack, Queue, Lists, Trees and Graphs in problem solving	Understand
CO4	Design an algorithm using divide and conquer method and analyze the different sorting algorithms	Analyse

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Pointers and Structures		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Pointers, Structures: Introduction, Nested Structures, Arrays of Structures, Structures and Functions, Self-Referential Structures	4	Nil
1.2	Introduction to Data Structures: Basic terminology, classification of data structures, operations on data structures, abstract data type	4	Nil
Module – 2: Trees			
2.1	Introduction, Types of Trees, Traversing A Binary Tree, Applications of Trees	4	Nil
2.2	Binary Search Trees, Operations on Binary Search Trees, Threaded Binary Trees: One- way Threading.	4	Nil
Module – 3: Searching & Sorting			
3.1	Sorting: Introduction to Sorting, Radix Sort, Heap Sort, Shell Sort, Tree Sort	3	Nil
3.2	Searching: Binary Search, Interpolation Search, Hashing and Collision: Introduction, Hash Tables, Hash Functions, Collisions, Different Hash Functions	3	Nil
Module – 4: Algorithm Performance Analysis			
4.1	Introduction, Space and Time Complexities	4	Nil
4.2	Asymptotic growth rate and notations. Case studies for performance analysis (Insertion sort).	4	Nil
Module – 5: Stacks			
5.1	Introduction, Array Representation of Stacks, Operations on a Stack, Linked Representation of Stacks, Operations on a Linked Stack	3	Nil
5.2	Applications of Stacks: Reversing a list, Parentheses checker, Conversion of an infix expression into a postfix expression	3	Nil

5.3	Evaluation of a postfix expression, Recursion. Queues: Introduction, Array Representation of Queues, Linked Representation of Queues, Types of Queues: Circular Queue, Deque.	2	Nil
	Total No. of Lecture Hours	**40**	
	Total No. of Tutorial Hours		**Nil**

Textbooks:

1. Alfred V. Aho, Jeffrey D. Ullman, John E. Hopcroft, "**Data Structures and Algorithms**", Addison Wesley Series in Computer Science and Information Press

Course Code: BEE515E **Course Name: Data Analytics & IoT**
Credits: 3 **L:T:P:S - 3:0:0:0**
SEE: 50% Marks **CIE: 50% Marks**
SEE Hours: 3 **Total Marks: 100**

Prerequisites if any	Nil
Learning objectives	1. To teach statistical foundations by demonstrating descriptive/inferential techniques and their engineering applications. 2. To train students in machine learning implementation through hands-on exercises in classification, regularization, and model validation. 3. To demonstrate IoT system design by analyzing architectures, sensor/actuator characteristics, and protocol selection for real-world deployments.

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Explain the fundamental concepts of data analytics	Understand
CO2	Discuss the fundamental concepts of Machine Learning	Understand
CO3	Describe the fundamental concepts of IoT	Understand
CO4	Apply the concepts of data analytics and IoT to implement a mini project	Apply

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Descriptive Statistics and Inferential Statistics		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Introduction, Descriptive Statistics – Graphical Approaches	2	Nil
1.2	Measures of Central Tendency & Dispersion	2	Nil
1.3	Probability Distributions	2	Nil
1.4	Inferential Statistics through tests.	2	Nil
Module – 2: Regression and ANOVA			
2.1	Introduction, Simple Linear Regression	2	Nil
2.2	Logistic Regression	2	Nil
2.3	Designing Engineering Experiments	2	Nil
2.4	The Analysis of Variance.	2	Nil
Module – 3: Machine Learning: Introduction and Concepts			
3.1	Introduction to Machine Learning, Supervised Learning, Unsupervised Learning	2	Nil
3.2	Classification, K Nearest Neighbors	1	Nil
3.2	Decision Trees	2	Nil
3.4	Regularization	1	Nil
3.5	Dimensionality Reduction, Cross Validation.	2	Nil
Module – 4: Overview of Internet of Things			
4.1	Introduction, IoT Architecture,	2	Nil
4.2	Application based IoT Protocols	2	Nil
4.3	Cloud Computing,	2	Nil
4.4	Fog Computing, Sensor Cloud	2	Nil
Module – 5: IoT Sensing and Actuation			
5.1	Introduction, Sensors	2	Nil
5.2	Sensor Characteristics	2	Nil
5.3	Sensing Types	2	Nil

5.4	Actuators, Actuator Types, Actuator Characteristics	2	Nil
	Total No. of Lecture Hours	40	
	Total No. of Tutorial Hours		Nil

Textbooks:

1. Montgomery, Douglas C., and George C. Runger. **"Applied statistics and probability for engineers".** John Wiley & Sons, 2010.
2. Hastie, Trevor, Robert Tibshirani, and Jerome Friedman. **"The elements of statistical learning: data mining, inference, and prediction"**. Springer Science & Business Media, 2009.

Reference Books:

1. Introduction to Data Analytics - NPTEL MOOC

Course Code: BEE515F
Credits: 3
SEE: 50% Marks
SEE Hours: 3

Course Name: Design and Implementation of Switched Mode Power Converters
L:T:P:S - 2:0:2:0
CIE: 50% Marks
Total Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To provide training in the design and fabrication of magnetic components for a switched mode power converter 2. To develop skills on the design and implementation of a closed loop control for a switched mode power converter 3. To provide hands-on experience on the design, implementation and testing of a switched mode power converter

Course Outcomes:

On the successful completion of the course, the student will be able to

COs		Bloom's level
CO1	Select Power Semiconductor switch for the switched mode power converter and design the snubber and driver circuits	Apply
CO2	Design and fabrication of magnetic components for a switched mode power converter	Apply
CO3	Design and implementation of a closed loop control for a switched mode power converter	Apply
CO4	Design, implementation and testing of a switched mode power converter.	Analyse

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Selection of Power Semiconductor Switches		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Switch and its uses, Desirable characteristics of an ideal switch, real switches, their types and characteristics, Operating BJT in active region-Class A amplifiers	2	Nil
1.2	Topologies and their analysis: Various circuit elements in a Buck/Boost/DC-AC power converter circuits, Current/voltage values/waveforms across various power circuit elements.	3	Nil
1.3	Snubber circuits for power devices, Snubber circuit design, Wave shaping circuits for driving the gate of MOSFET/IGBTs, Pulse width modulator ICs	3	Nil
Module – 2: Magnetic components and their design			
2.1	Design of Magnetics: Design of inductors and transformers	2	Nil
2.2	Selection of ferrite cores, conductors, bus bars for the power circuits	3	Nil
2.3	Design of power circuits: Sizing and selection of power semiconductor devices, switchgears, inductors and capacitors used in the power circuit	3	Nil
Module – 3: Switch Mode Power Converter and their design			
3.1	Guidelines for building a power circuit layout and interfacing the control circuit with power circuits in view of protection and safety	2	Nil
3.2	Current/voltage sensors and their selection. Scaling and processing of feedback signals	2	Nil
3.2	Simplified closed loop control of Power converters: Implementation of P, P+I controllers using operational amplifiers or digital signal controllers	2	Nil
3.4	Design of switch mode Power supplies: Design and closed loop control of power converter from the given terminal specifications. Layout and Thermal design of power circuits; cooling of power switching devices	3	Nil
	Total No. of Lecture Hours	25	
	Total No. of Tutorial Hours		Nil

List of experiments:

Sl. No.	Experiment	Hands on/ Virtual
1	Preparing circuit schematics and circuit building	Hands on
2	Data sheet reading of power semiconductor devices, their power loss computations and Circuit simulation of power converters	Hands on
3	PWM controller circuit design, generation of waveforms and interfacing with MOSFET	Hands on
4	Data sheet reading of Magnetic core catalog, Identification of magnetic components, reading the data sheet of wires and cores	Hands on
5	Design and validation of design of high frequency inductors; Correlating (Ac * Aw) product with the type of core, selection of the core, conductor and insulators for the given design; Sourcing of specified components and building/fabricating inductor for the given specifications.	Hands on
6	Design and validation of design of high frequency transformers: Sourcing of specified components and building/fabricating inductor and transformer for the given specifications.	Hands on
7	Design, testing and performance evaluation of power converters	Hands on
8	8. Characterization of the voltage and current sensors and comparing with their data sheets. Design, fabrication and performance analysis of Current and Voltage sensors signal processing circuits	Hands on
9	Implementation closed loop controller for power converters. Plotting the frequency response of the system and design of the closed loop controller to determine the crossover frequency, gain margin and phase margin by simulation using MATLAB	Hands on
10	Building of Flyback/Forward/full bridge converters. Testing, performance analysis, waveform recording and result tabulation for the power converter built	Hands on

Reference Materials:

1. L Umanand, **"Power Electronics, Essentials and Applications",** 1st Edition, Wiley India Pvt. Ltd., 2009.
2. Datasheets of hall effect current and voltage sensors: https://www.lem.com/en/voltage-transducers
3. **Catalogue of ferrite magnetic cores:** https://www.mag-inc.com/Media/Magnetics/File-Library/Product%20Literature/Ferrite%20Literature/Magnetics-2022-Ferrite-Catalog.pdf?ext=.pdf

B.E Electrical and Electronics Engineering

(2022-2026)

Syllabus – VI Semester

Department of Electrical and Electronics Engineering

The National Institute of Engineering

Mysuru-570 008

Course Code: BEE601
Credits: 4
SEE: 50% Marks
SEE Hours: 3

Course Name: Switchgear and Protection
L:T:P:S - 3:0:2:0
CIE: 50% Marks
Total Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To teach students protection system components 2. To train students in relay coordination 3. To prepare students to design protection schemes 4. To develop students' skills on the analysis of protection systems with hands-on experiments using laboratory prototypes.

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Discuss the fundamental concepts of power system protection and switch gears.	Understand
CO2	Describe the technology of protection which forms the base for revolution in protection	Understand
CO3	Analyse and identify different protective schemes to be employed in a Generator, Transformer and Motor	Analyse
CO4	Describe the construction and principle of operation of different circuit breakers.	Understand

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Introduction to Power System Protection		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Nature and causes of faults, types of faults, effects of fault. Basic Relay Terminologies.	2	Nil
1.2	Need of protection, Zones of protection, primary and backup protection. Essential qualities of Protective Relaying, components of protection system, CTs and PTs for protection.	3	Nil
1.3	Classification of Protective Relays- attracted armature relays, induction relays, thermal relays, Numerical relay.	2	Nil
Module – 2: Protective Relaying Behaviour			
2.1	Over current relays- instantaneous time current relays, IDMT characteristics.	2	Nil
2.2	Directional relays, Differential relay – Principle of operation, percentage differential relay.	3	Nil
2.3	Bias characteristics. Distance relays – Three stepped distance protection, effect of line length and source impedance on performance, Impedance relay, Reactance relay, Mho relay. Auxiliary Relay, Seal in Relay.	3	Nil
Module – 3: Protection Schemes			
3.1	Generator Protection–generator faults, stator protection, rotor protection.	2	Nil
3.2	Protection against abnormal conditions, Transformer Protection– transformer faults, Differential protection. Differential relay with harmonic restraint.	3	Nil
3.3	Induction Motor Protection - protection against electrical faults such as phase fault, ground fault, and abnormal operating conditions.	3	Nil
Module – 4: Switches and Fuses			
4.1	Definition of switchgear, switches - isolating, load breaking and earthing switches. Power Contactors.	3	Nil
4.2	Introduction to fuse, fuse law, cut-off characteristics, Time current characteristics, fuse material.	3	Nil

4.3	Types of Fuses- open type, semi enclosed re-wirable type, D type cartridge fuse, HRC fuse and their applications.	2	Nil
Module – 5: Principles of Circuit Breakers			
5.1	Introduction, Arcing, Arc Interruption Theory- recovery rate theory and energy balance theory. Re-striking voltage, recovery voltage, RRRV, resistance switching, capacitance switching and current chopping.	3	Nil
5.2	Types of Circuit Breakers: Air Circuit breakers–Air break and Air blast Circuit breakers. Plain break Oil Circuit Breakers, MOCB, SF6 breaker - Puffer and non Puffer type of SF6 breakers.	3	Nil
5.3	Vacuum Circuit Breakers - principle of operation and constructional details. High voltage direct current circuit breakers, Testing of Circuit breakers-Unit testing, synthetic testing. Rating of Circuit Breaker	3	Nil
	Total No. of Lecture Hours	40	
	Total No. of Tutorial Hours		Nil

List of Experiments:

Sl. No.	Experiment	Hands on/ Virtual
1	Operating characteristics of static over-voltage relay and static under-voltage relay	Hands on
2	Current-time characteristics of Fuse.	Hands on
3	Operating characteristics of microprocessor based over-current relay	Hands on
4	Operating characteristics of microprocessor based over/under voltage relay	Hands on
5	Study the performance of Negative sequence relay	Hands on
6	Operating Characteristics microprocessor-based Distance Relay.	Hands on
7	Operating Characteristics Numerical based Differential Relay.	Hands on
8	Simulation study of Feeder protection schemes of Radial feeder	Hands on
9	Simulation study of Generator protection schemes	Hands on
10	Simulation study of Induction Motor protection schemes	Hands on

Textbooks:

1. Sunil S.Rao, **"Switchgear and Protection",** 13th edition, Khanna Publishers, 2008.
2. Badriram and Viswa Kharma, **"Power System Protection and Switchgear",** 2nd edition, TMH, 2010.

Reference Books:

1. Chakrabarti, Soni, Gupta and Bhatnagar, **"A Course in Electrical Power",** Dhanpat Rai and Sons.
2. Ravindarnath and Chandar, **"Power System Protection and Switchgear",** NewAge Publications.

Course Code: BEE602 **Course Name: Power System Analysis - II**
Credits: 4 **L:T:P:S - 2:2:2:0**
SEE: 50% Marks **CIE: 50% Marks**
SEE Hours: 3 **Total Marks: 100**

Prerequisites if any	Power System Analysis - 1
Learning objectives	1. To teach students load flow analysis methods 2. To train students in stability assessment 3. To prepare students to solve economic dispatch problems 4. To develop students' power system simulation skills

Course Outcomes:

On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Compute Network matrices for power system networks	Analyse
CO2	Apply numerical techniques to evaluate the power flows and stability of power systems.	Apply
CO3	Analyze stability aspects of power system.	Analyse
CO4	Conduct power flow analysis and transient analysis on a power system using software simulation.	Analyse

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Network Topology		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Elementary graph theory – oriented graph, tree, co-tree	1	Nil
1.2	Incidence matrices – Element-node, Bus incidence, branch path, Basic cut-set, Augmented cut-set, Basic loop, Augmented loop	2	2
1.3	Numerical Problems on incidence matrix formation	1	Nil
Module – 2: Network Matrices			
2.1	Formation of Y_{BUS} matrix by method of inspection (including transformer off-nominal tap setting), Numerical	1	Nil
2.2	Formation of Y_{BUS} matrix by singular transformation method, Numerical	2	2
2.3	Formation of Bus Impedance matrix, Numerical	2	Nil
Module – 3: Load Flow Analysis			
3.1	Power flow equations, Classification of buses, Operating constraints, Data for load flow	1	Nil
3.2	Gauss - Siedal Method - Algorithm and flow chart for PQ and PV buses	2	Nil
3.3	Acceleration of convergence; Newton Raphson Method – Algorithm and flow chart for NR method in polar coordinates	1	2
3.4	Algorithm for Fast Decoupled load flow method	1	Nil
Module – 4: Stability Analysis			
4.1	Classification of power system stability, Swing equation, Power angle equation	1	Nil
4.2	Steady state stability, steady state stability of a two machine system	2	Nil
4.3	Transient stability, Equal Area Criterion (EAC), Applications of Equal Area Criterion	2	2
Module – 5: Transient Stability Analysis using Numerical Methods, Voltage Stability			
5.1	Numerical solution of Swing Equation – Point-by- point method	1	Nil
5.2	Modified Euler's method, Runge-Kutta method, Milne's predictor corrector method	1	2
5.3	Network performance equations, Solution techniques with flow charts	1	Nil

5.4	**Voltage Stability:** Comparison of angle and voltage stability, reactive power flow, Voltage collapse, mathematical formulation of voltage stability problem	2	Nil
5.5	Voltage stability analysis, prevention of voltage collapse	1	Nil
	Total No. of Lecture Hours	**25**	
	Total No. of Tutorial Hours		**10**

List of Experiments:

Sl. No.	Experiment	Hands on/ Virtual
1	Formation of incidence matrix for a given power system using MATLAB.	Hands on
2	Computation of Y-Bus matrix for a given power system by inspection method using MATLAB.	Hands on
3	Computation of Y-Bus matrix for a given power system by singular transformation method using MATLAB.	Hands on
4	Determination of Bus Currents, Bus Power and Line Flow for a Specified System Voltage (Bus) Profile using MATLAB.	Hands on
5	Computation of Z-Bus matrix for a given power system by building algorithm method using MATLAB.	Hands on
6	Perform Load flow analysis on a Power System in ETAP platform.	Hands on
7	Perform Transient analysis on a single machine connected to an infinite bus using ETAP for load addition and load rejection transients.	Hands on
8	Perform Transient analysis on two machines connected to an infinite bus using ETAP for three-phase fault transient.	Hands on
9	Simulate a step change in load in a single area system with load frequency control and compute the maximum frequency deviation using MATLAB.	Hands on
10	Simulate a step change in load in a two-area system with load frequency control and compute the tie line power flow using MATLAB.	Hands on

Textbooks:

1. Stag, G. W., and EI-Abiad**, "Computer Methods in Power System Analysis",** A. H.- McGraw Hill International Student Edition. 1968.
2. Nagrath, I. J and Kothari**, "Modern Power System Analysis",** D. P, TMH, 3rd Edition, 2003

Reference Books:

1. HaadiSadat, **"Power System Analysis"**, TMH, 2nd Edition, 12th reprint, 2007

Course Code: BEE603
Credits: 3
SEE: 50% Marks
SEE Hours: 3

Course Name: Electric Vehicles
L:T:P:S - 3:0:0:0
CIE: 50% Marks
Total Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To teach students EV drivetrain components 2. To provide insight into battery parameters and the modeling of Li-ion battery 3. To prepare students to analyze power converters used in traction path and battery chrging 4. To develop EV simulation skills

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Analyse the dynamics of Electric vehicles and size the Traction motor	Analyze
CO2	Apply Power Electronics, Electric Motor and Battery Technologies for Electric Vehicles	Apply
CO3	Analyse the Controllers of Electric Traction Machines.	Analyze
CO4	Design, model and simulate different components of Electric Vehicles.	Apply

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Introduction to Electric Vehicles and its Modeling		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Environmental Impact of Electric Vehicle, Types of Electric Vehicles, Components of Electric Vehicle	2	Nil
1.2	Vehicle load forces: aerodynamic drag, rolling resistance, grading resistance	2	Nil
1.3	Mathematical Model of vehicle to describe vehicle performance, Sizing of traction motor.	2	Nil
1.4	Drive Cycles, Modelling of Electric Vehicle dynamics using MATLAB/SIMULINK	2	Nil
Module – 2: Batteries for EV			
2.1	Energy storage systems and its Types, desirable features of batteries for electric vehicle application, Basic operation of Li-ion cell.	2	Nil
2.2	Battery parameters – battery capacity, open circuit voltage, terminal voltage, practical capacity, discharge rate, state of charge, state of discharge, depth of discharge, battery energy, specific energy, battery power, specific power.	2	Nil
2.3	Charging modes of battery, Modelling of Li-ion battery considering ohmic resistance, diffusion voltage and the effect of SOC on the terminal voltage.	2	Nil
2.4	Battery failures: causes and its impacts, USABC Objectives for EV Advanced Battery Packs, Battery simulation using MATLAB/SIMULINK	2	Nil
Module – 4: Power Electronics of EV			
3.1	Power conversion in EV – Isolated bidirectional DC/DC Converter in power train path, Dual Active Bridge, DC/AC converter to control the motor.	3	Nil
3.2	Power Electronics for Battery Charging Systems, charging architectures, low power charger circuit, Automotive standard charger circuit, Conductive battery charging circuit.	3	Nil
3.3	Boost converter for power factor correction, MATLAB Simulation of Open loop and	2	Nil

	closed loop Buck Boost Converter and Battery Charging/Discharging Controller.		
Module – 4: EV Motors			
4.1	Drivetrain systems for EV, Characteristic curves of a traction machine, Requirements of EVs on Electric Motor Drives.	2	Nil
4.2	Working of major motor drives of EVs in constant torque and constant power modes: Wound Field DC Motor Drives, Induction Motor Drives, PMBLDC Motor Drives and SRM Drives.	4	Nil
4.3	DC Motor Drive simulation using MATLAB/SIMULINK.	2	Nil
Module – 5: Control of Electric Traction Machines			
5.1	Induction motor control: Variable Voltage Variable- Frequency Control, Field-Oriented Control and Direct Torque Control.	4	Nil
5.2	Permanent Magnet Brushless Motor Control: Field-Oriented Control of PM Synchronous Motor, Flux-Weakening Control of PM Synchronous Motor, Phase-Advance Angle Control of PM Brushless DC Motor	2	Nil
5.3	Switched Reluctance Motor control: current chopping control (CCC), advance angle control (AAC), Torque-Ripple Minimization Control. (qualitative treatment only), Position Sensorless Control of SRM	2	Nil
	Total No. of Lecture Hours	40	
	Total No. of Tutorial Hours		Nil

Textbooks:

1. John G. Hayes, G. Abas Goodarzi, **"Electric Powertrain - Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles",** Wiley, 2018.
2. K. T. Chau, "Electric Vehicle Machines and Drives -Design, Analysis and Application", Wiley 2015.
3. Iqbal Husain**, "Electric and Hybrid Vehicles Design Fundamentals",** 2nd Edition, CRC Press Taylor & Francis Group, 2011

Reference Books:

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, **"Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design",** CRC Press, 2004

Course Code: BEE604
Credits: 3
SEE: 50% Marks
SEE Hours: 3

Course Name: Digital Signal Processing
L: T:P:S - 3:0:0:0
CIE: 50% Marks
Max. Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To provide insight into digital signal analysis 2. To train students in filter design 3. To prepare students to implement DSP algorithms 4. To develop students' MATLAB programming skills

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Discuss the fundamentals of signals, systems, their classification and understand the time domain representation of LTI systems	Understand
CO2	Realise digital filters in direct form I and II, Parallel and Cascade.	Apply
CO3	Design and simulate IIR and FIR filters.	Apply

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Introduction		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Definitions of Signal and a System, Classification of signals, basic operations on signals, elementary signals, properties of systems.	3	Nil
1.2	Generation of various signals and sequences such as unit impulse, step, square, saw tooth, triangular, sinusoidal, ramp etc	3	Nil
1.3	Performing basic operations on signals; using MATLAB/Python	2	Nil
Module – 2: Discrete Fourier Transforms			
2.1	Definitions, properties-linearity, shift, symmetry, time shift, frequency shift etc.,	2	Nil
2.2	circular convolution – periodic convolution, use of tabular arrays, circular arrays, Stock Ham's methods	3	Nil
2.3	linear convolution – two finite duration sequences, one finite & one infinite duration.	3	Nil
Module – 3: Realisation of Digital Systems			
3.1	Introduction, block diagrams, and SFGs, matrix representation	2	Nil
3.2	realisation of IIR systems- direct form, parallel form, ladder structures for equal degree polynomial,	3	Nil
3.3	realisation of FIR systems – direct form, cascade form realisation	3	
Module – 4: Design of IIR Digital Filters			
4.1	Introduction, impulse invariant & bilinear transformations	3	Nil
4.2	All pole analog filters- Butterworth &Chebyshev, design of digital Butterworth & Chebyshev, frequency transformations.	4	Nil

Module – 5: Design of FIR Digital Filters			
5.1	Introduction, windowing, rectangular, modified rectangular techniques	4	Nil
5.2	Hanning, Blackman window, frequency sampling techniques.	4	Nil
	Total No. of Lecture Hours	40	
	Total No. of Tutorial Hours		Nil

Textbooks:

1. Alan V Oppenheim, Alan S.Willsky and S. Hamid Nawab Proakis,**"Digital Signal Processing Principle, Algorithm & application"**, Pearson Education/PHI.
2. Johnny R, **"Introduction to Digital Signal Processing"**, Johnson- PHI.
3. Sanjeet. K. Mitra**, "Digital Signal Processing",** TMH.

Reference Books:

1. Michel J Roberts**, "Signals and Systems: Analysis of signals through Linear Systems**", Tata McGraw Hill, 2011.
2. B.Venkataramani, M.Bhaskar, **"Digital Signal Processors, Architecture Programming and applications",** Tata Mc-Graw Hill.

Course Code: BEEL605
Credits: 1
CIE: 50% Marks
SET Hours: 2

Course Name: Digital Signal Processing Lab
L:T:P:S – 0:0:2:0
SET: 50% Marks
Total Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To develop skills on the design and implementation of Digital Signal Processing algorithms in MATLAB/ OCTAVE platform

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Design and implementation of Digital Signal Processing algorithms in MATLAB/ OCTAVE platform	Apply

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

List of Experiments:

Sl. No.	**Experiment**	**Hands on/ Virtual**
1	Verification of sampling theorem.	Hands on
2	Zero-input response of a given system	Hands on
3	Impulse response of a given system	Hands on
4	Linear convolution of two given sequences	Hands on
5	Circular convolution of two given sequences	Hands on
6	Solving a given differential equation	Hands on
7	Solving a given difference equation	Hands on
8	Computation of N point DFT of a given sequence and to plot magnitude and phase spectrum	Hands on
9	Design and implementation of FIR filter to meet given specifications.	Hands on
10	Design and implementation of IIR filter to meet given specifications	Hands on

Textbooks:

1. Alan V Oppenheim, Alan S.Willsky and S. Hamid Nawab Proakis,**"Digital Signal Processing Principle, Algorithm & application"**, Pearson Education/PHI.

Course Code: BEE613A
Credits: 3
CIE: 50% Marks
SEE Hours: 3

Course Name: Soft Computing Techniques
L:T:P – 3:0:0:0
SEE: 50% Marks
Total Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To teach students fuzzy logic applications 2. To train students in neural network implementation 3. To prepare students to develop intelligent controllers

Course Outcomes:

On the successful completion of the course, the student will be able to

COs		Bloom's level
CO1	Explain fuzzy sets, methods of fuzzy logic and fuzzy mathematics.	Understand
CO2	Explain the Artificial Neuron Models, functions and apply the various learning rules of Neural Networks.	Apply
CO3	Explain the various Neuro -fuzzy controller technique	Understand
CO4	Apply the concepts of soft computing techniques to implement mini project	Apply

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Fuzzy Control		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Fuzzy Logic, Fuzzy Sets, Membership Functions - Piecewise Linear MF,	2	Nil
1.2	Nonlinear Smooth MF, Sigmoidal MF, Polynomial or Spline-Based Functions, Irregular Shaped MF, Linguistic Variables,	2	Nil
1.3	Fuzzy If–then Rules, Fuzzy Proposition,	2	Nil
1.4	Methods for Construction of Rule-Base	2	Nil
Module – 2: Fuzzification and Defuzzification:			
2.1	Fuzzification - Inference Mechanism Mamdani Fuzzy Inference,	3	Nil
2.2	Sugeno Fuzzy Inference, Tsukamoto Fuzzy Inference, Defuzzification,	3	Nil
2.3	Defuzzification Methods, Properties of Defuzzification	2	Nil
Module – 3: Artificial Neural Networks			
3.1	Introduction Neural Networks, Biological Neuron, Biological and Artificial Neuron Models, types of Neuron Activation function.	2	Nil
3.2	ANN Architectures, supervised, and unsupervised learning, Perceptron Models, training Algorithms,	2	Nil
3.3	Limitations of the Perceptron Model and Applications,	2	Nil
3.4	Computer based simulation.	2	Nil
Module – 4: ANN Paradigms			
4.1	Multilayer Feed forward Neural Networks - Back propagation Algorithm, Limitations of Back propagation Algorithm, Radial Basis	3	Nil
4.2	Function network structure - covers theorem and the separability of patterns - RBF learning strategies.	3	Nil

4.3	Applications in forecasting and pattern recognition and other engineering problems, Computer based simulation	2	Nil
Module – 5: Neuro-Fuzzy Control			
5.1	Combinations of Neural Networks and Fuzzy Controllers - NN for Correcting FLC, NN for Learning Rules, NN for Determining MFs, NN for Learning/Tuning Scaling Parameters.	3	Nil
5.2	Scaling Parameters of PD-PI Fuzzy Controller, Reducing the Number of Scaling Parameters,	2	Nil
5.3	Neural Network for Tuning Scaling Factors, Backpropagation Learning with Linear Activation Function, Learning with Non-Linear Activation Function.	3	Nil
	Total No. of Tutorial Hours	40	
	Total No. of Tutorial Hours		Nil

Textbooks:

1. Nazmul Siddique, **"Intelligent Control A Hybrid Approach Based on Fuzzy Logic, Neural Networks and Genetic Algorithms",** Springer International Publishing Switzerland, 2014
2. S.Rajasekaran and G.A.V.Pai,"**Neural Networks, Fuzzy Logic & Genetic Algorithms"**, PHI, New Delhi, 2003.

Reference Book*:*

1. Robert J. Schalkoff, "**Artificial Neural Networks"**, Tata McGraw Hill Edition, 2011.

Course Code: BEE613B **Course Name: Introduction to Battery Management Systems**
Credits: 3 **L:T:P – 3:0:0:0**
CIE: 50% Marks **SEE: 50% Marks**
SEE Hours: 3 **Total Marks: 100**

Prerequisites if any	Nil
Learning objectives	1. To provide training on battery modeling 2. To train students in SOC and SOH estimation 3. To prepare students to design balancing circuits

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Understand the terminologies and working of batteries.	Understand
CO2	Develop Equivalent-Circuit Models of Lithium-ion Battery.	Apply
CO3	Describe requirements and functionalities of a BMS.	Understand
CO4	Analyse the methods of Battery SOC, SOH Estimation, Cell balancing and Computation of power limits.	Analyse

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Introduction to Battery Technology		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Introduction to battery terminologies: Cell voltage, cell nominal charge capacity, cell nominal energy capacity, Specific energy and energy density	3	Nil
1.2	Working of a cell, Working of Li-ion Cells: Negative electrode, Positive electrode, Electrolyte, Separator, Current Collectors, Charging and Discharging	3	Nil
1.3	Manufacturing of Li-ion cells, Ageing, Uncontrolled operating conditions and abuses of Battery.	2	Nil
Module – 2: Equivalent Circuit Modelling of Battery Packs			
2.1	Equivalent-Circuit Models: Open-circuit voltage (OCV), State-of-charge dependence, Equivalent series resistance, Diffusion voltages, Warburg impedance, Hysteresis voltages	4	Nil
2.2	Enhanced self-correcting cell model, Effect of ageing on Total capacity and Equivalent Series Resistance, Negative-electrode aging, Positive electrode aging.	4	Nil
Module – 3: Battery Management System Design Requirements			
3.1	Purposes of a battery- management system, Battery-pack sensing of Voltage, Temperature and Current	3	Nil
3.2	High-voltage contactor control, Isolation sensing, Thermal control, Protection, Charger control	3	Nil
3.3	Communication via CAN bus, Log book function, State of charge estimation, Energy estimation, Power estimation, SOH estimation.	2	Nil
Module – 4: Battery State of Charge and Health Estimation			
4.1	**Battery State of Charge Estimation:** Definition of State of Charge, Classification of SOC estimation methods, Estimation method based on	2	Nil

	characteristic parameters		
4.2	Ampere-hour integral estimation method, Model-based estimation method, Data-driven estimation (qualitative approach only).	2	Nil
4.3	**Battery State of Health Estimation:** Sensitivity of voltage to Equivalent Series Resistance, Sensitivity of voltage to total capacity, Estimating SOH parameters	2	Nil
4.4	Classification of SOH estimation method, Direct measurement methods, Indirect analysis methods, Adaptive algorithms, Data-driven based methods (qualitative approach only).	2	Nil
Module – 5: Cell Balancing and Power Limit estimation			
5.1	**Cell Balancing:** Causes of imbalance, Balancer design choices, Circuits for balancing: Fixed shunt resistor, Switched shunt resistor, Multiple switched capacitors, One switched capacitor, Switched transformer, Shared transformer, Shared bus.	4	Nil
5.2	**Power Limit estimation:** Terminal-voltage-based power limits, Voltage-based power limits, using a simple cell model, Rate limits based on SOC, maximum current and power, Voltage- based power limits using a full cell model.	4	Nil
	Total No. of Lecture Hours	**40**	
	Total No. of Tutorial Hours		**Nil**

Textbooks:

1. Gregory L. Plett, "**Battery Management Systems, Vol. 1, Battery Modeling**", Artech House, 2015.
2. Gregory L. Plett, "**Battery Management Systems, Volume II, Equivalent-Circuit Methods**", Artech House, 2016

Reference Books:

1. Rui Xiong, "**Battery Management Algorithm for Electric Vehicles"** Springer publications 2020.

Course Code: BEE613C
Credits: 3
SEE: 50% Marks
SEE Hours: 3

Course Name: Machine Learning
L:T:P - 3:0:0
CIE: 50% Marks
Total Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To provide insight into the fundamentals of Machine learning theories. 2. To explore and implement various ML algorithms.

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Understand and explore the fundamentals of Machine Learning concepts and various learning theory.	Understand
CO2	Evaluate the various machine learning Algorithms and its mathematical background.	Apply
CO3	Implement various Machine Learning concepts and Algorithms using Python.	Apply

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Introduction to Machine Learning and Data - Preprocessing.		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Introduction to Machine Learning: Need for ML, Types of ML,	1	Nil
1.2	ML Process and Applications.	1	Nil
1.3	Understanding Data: Types of Data, Data storage and Representations	1	Nil
1.4	Data collection and Data Preprocessing,	1	Nil
1.5	Descriptive Statistics, Univariate Data Analysis and Visualization, Bivariate and Multivariate Data.	1	Nil
1.6	Overview of Hypothesis – t-test and paired t-test	3	Nil
1.7	Implementation of various data pre-processing techniques using Python	1	Nil
Module – 2: Basics of learning and Similarity Based Learning			
2.1	Basics of Learning: Introduction to learning and its types,	1	Nil
2.2	Concept Learning, Induction Biases, Bias and Variance Tradeoff	2	Nil
2.3	PAC and Dimensionality Reduction	1	Nil
2.4	Overfitting and Underfitting and Modelling in Machine Learning.	1	Nil
2.5	Similarity Based Learning: Nearest Neighbor-Learning, Weighted K-Nearest Neighbor-Learning	2	Nil
2.6	Nearest Centroid Classifier	1	Nil
2.7	Implementation of k-NN using Python	1	Nil
Module – 3: Regression analysis and Decision tree			
3.1	Introduction to regression, Introduction to Linearity, Correlation and Causation.	1	Nil
3.2	Introduction to Linear regression, Validation of Regression Methods.	1	Nil
3.2	Multiple Regressions.	1	Nil
3.4	Decision Tree Learning Model: Fundamentals of Entropy,	1	Nil
3.5	ID3 Algorithm and CART Algorithm	2	Nil
3.6	Regression Trees	1	Nil
3.7	Implementation of Linear regression and Decision Tree algorithm using Python	1	Nil

Module – 4: Bayesian Learning and Probabilistic Graphical Models			
4.1	Bayesian Learning: Bayes' theorem, Classification using bayes Model- Naïve Bayes Algorithm	1	Nil
4.2	Gaussian Naïve bayes Algorithm.	2	Nil
4.3	Probabilistic Graphical Models: Bayesian Belief Network,	2	Nil
4.4	Markov Chain – Markov Model	1	Nil
4.5	Implementation of Naïve Bayes Algorithm and BBN using Python	1	Nil
Module – 5: Clustering Algorithms and Reinforcement Learning			
5.1	Introduction, Proximity Measures, Hierarchical Clustering Algorithm – MIN Algorithm	2	Nil
5.2	Partitional Clustering Algorithm- K means Algorithm.:	2	Nil
5.3	Components of RL, Marko Decision Process,	2	Nil
5.4	Passive Learning and Q learning	1	Nil
5.5	Implementation of Clustering algorithms using Python	1	Nil
	Total No. of Lecture Hours	40	
	Total No. of Tutorial Hours		Nil

Textbooks:

1. S. Sridhar, M. Vijayalakshmi**, "Machine Learning"**, Oxford University Press
2. Mitchell, T. M., **"Machine learning",** McGraw-hill New York.

Reference Books:

1. U Dinesh Kumar Manaranjan Pradhan, **"Machine Learning with Python",** Wiley

Course Code: BEE613D
Credits: 3
SEE: 50% Marks
SEE Hours: 3

Course Name: Electrical Machine Design
L: T:P:S - 3:0:0:0
CIE: 50% Marks
Max. Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To equip students to design key components of DC and AC machines 2. To train students in material selection, dimensioning, and performance estimation. 3. To prepare students to solve industry-relevant machine design problems.

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Explain the basic principles of machine design.	Understand
CO2	Design the main dimensions of the transformer core, transformer tank, cooling tubes and estimate the no load current based on design data	Apply
CO3	Design the main dimension of the DC Machine and AC Machines	Apply
CO4	Sketch the design diagrams of electric machines using AUTOCAD software.	Apply

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Principles of Electrical Machine Design		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Introduction, considerations for the design of electrical machines, limitations	3	Nil
1.2	Different types of materials and insulators used in electrical machines. Output equation of DC Machines	2	Nil
1.3	Choice of specific loadings and choice of number of poles, design of main dimensions of the DC machines	2	Nil
Module – 2: Design of Transformer - I			
2.1	Output equation for single phase and three phase transformer	2	Nil
2.2	Choice of specific loadings, expression for volts/turn	2	Nil
2.3	Determination of main dimensions of the core.	4	Nil
Module – 3: Design of Transformer - II			
3.1	Estimation of number of turns and cross sectional area of Primary and secondary coils of transformers	4	Nil
3.2	Estimation of no-load current, expression for leakage reactance of transformer.	4	Nil
Module – 4: Design of Induction Machine			
4.1	Output equation of induction machine, Choice of specific loadings, , main dimensions of three phase induction motor	3	Nil
4.2	Stator design. choice of length of the air gap	3	Nil
4.3	Estimation of number of slots for the squirrel cage rotor, design of Rotor bars and end rings.	3	Nil

Module – 5: Design of Synchronous Machine			
5.1	Output equation of a synchronous machine, Choice of specific loadings, design of main dimensions.	3	Nil
5.2	Slot details for the stator of salient and non-salient pole synchronous machines.	2	Nil
5.3	Design of rotor of salient pole synchronous machines, design of the field winding design of rotor of non-salient pole machine.	3	
	Total No. of Lecture Hours	40	
	Total No. of Tutorial Hours		Nil

Textbooks:

1. A. K. Sawhney, **"A Course In Electrical Machine Design",** 6th edition, Dhanpat Rai and Co, 2014.
2. V. N. Mittal, A. Mittal, **"Design of Electrical Machines",** 5th edition, Oscar Publication, Delhi, 2009.

Reference Books:

1. M. G. Say, **"Performance and Design of AC Machines".**
2. R. K. Aggarwal, **"Principles of Electrical Machine Design".**
3. Shanmugasundaram, Gangadharan, and Palani, **"Design Data Handbook",** 1st edition, New Age International

Course Code: BEE613E **Course Name: Embedded Controllers for Power Converters**
Credits: 3 **L:T:P – 1:0:4:0**
CIE: 50% Marks **SEE: 50% Marks**
SEE Hours: 3 **Total Marks: 100**

Prerequisites if any	Nil
Learning objectives	1. To teach students DSC programming 2. To train students in power converter control 3. To prepare students to implement controllers for power converters

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Understand functioning and programming of various peripherals of Digital Signal Controller TMS320F28379D and apply them for the implementation of control strategies for Power Converters	Apply
CO2	Design, Interface and test various analog and, digital control circuits to power circuits of Buck/Boost Power converters	Analyse

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Digital Signal Controller TMS320F28379D and its peripherals		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	About the course, Importance of DSC in power converters	1	Nil
1.2	Analog v/s Digital signal processing, Digital Signal Processing System, Major features of uC, uP and DSP	1	Nil
1.3	Architectural features of DSP, Number formats in DSC, Fixed point versus Floating point methods, Computational building blocks; Bus architecture and memory	1	Nil
1.4	Reading the data sheets of TMS320F28379D to know the specifications of processor, its features and peripherals; Block diagram. Various types of memory, sources of clocks, Power supply requirements	Nil	2
1.5	Review digital electronics, Concept of peripherals of DSC:TMS320F28379D, GPIO,TIMER, REGISTERS	1	Nil
1.6	PWM, ADC, INTERUPT, QEP, SPI, SCI, JTAG, System components, Memory organization, Mapping of Memory. peripherals and their control registers.	1	Nil
Module – 2: Introduction to IDE, GPIO, Interrupts and Timers			
2.1	Introduction to IDE Code composer studio CCS 7.3, creating project, adding header files, writing code using 'C', Steps involved in HL language development, Review of basics of 'C' language Hands-on working	Nil	2
2.2	System clock / PLL Module, setting up and configuring the clock to the processor, Low power modes of the processor	1	Nil
2.3	GPIO basic unit and its controls, Multiplexing, I/O configuration/control registers	1	Nil
2.4	Introduction to GP timers, Timer control registers	1	Nil
2.5	Introduction to interrupts and interrupts priority, Interrupt control registers, triggering an interrupt using timer (Hands on)	1	Nil
Module – 3: PWM, ADC, Quadrature Encoders and Communication			
3.1	Introduction to ADC module, SOC	1	Nil
3.2	ADC control registers, Various methods of trigger to start the AD Conversion	1	2
3.3	Introduction to PWM Module	1	Nil

3.4	Generation of PWM pulses, PWM control registers, interrupts	Nil	2
3.5	Introduction to Capture and Q-Encoder module, Quadrature encoder and its control registers	Nil	2
3.6	Introduction to Serial Communication Interface (UART), Control of registers SCI	1	Nil
3.7	Serial Peripheral Interface (SPI)	1	Nil
	Total No. of Lecture Hours	**15**	
	Total No. of Tutorial Hours		**10**

List of Experiments:

Sl. No.	Experiment	Hands on/ Virtual
1	Read the data sheet of TMS320F28379D (SPRS880K)	Hands on
2	Familiarisation of IDE / CCS - Interfacing the Laptop to Launch pad TMS320F28379D processor and testing using basic C programs	Hands on
3	General Purpose Input / Output	Hands on
4	GP timer and interrupts	Hands on
5	Interrupts	Hands on
6	Analog to Digital Converter	Hands on
7	Pulse Width Modulator (PWM)	Hands on
8	Communication through UART (SCI)	Hands on
9	Input/output X-Bars, Comparator Sub system (CMPSS), Trip Zone & Digital	Hands on
10	Serial Peripheral Interface (SPI)	Hands on

Reference Books:

1. Muhammad H. Rashid, **"Power Electronics Devices, Circuits, and Applications"**, fourth edition, Pearson Education Limited, England, 2014.

Reference Materials:

1. http://ti.com/products (spruhm8h-28379D-Tech Reference Manual)
2. http://ti.com/products (sprs880k-28379D Datasheet)
3. Code Composer Studio User's Guide, Texas Instruments.

Course Code: BEE613F
Credits: 3
L:T:P:S - 3:0:0:0
SEE Hours: 3 Hrs

Course Name: Circular Economy and Sustainability for Electrical Engineers
CIE: 50% Marks
SEE: 50% Marks
Max. Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To introduce sustainability concepts and circular economy principles relevant to electrical engineering. 2. To examine environmental impacts of electrical systems and materials across their life cycles. 3. To equip students with tools to design, assess, and innovate sustainable electrical systems and products.

Course Outcomes:

On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Discuss the principles of sustainability and circular economy and their application in electrical engineering.	Understand
CO2	Apply sustainable and circular design strategies to electrical systems and energy solutions.	Apply
CO3	Analyze the environmental and lifecycle impacts of electrical equipment and systems.	Analyse

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module 1: Fundamentals of Sustainability and Circular Economy		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Introduction to Sustainability: TBL, SDGs, and Climate Context	2	Nil
1.2	Circular Economy vs Linear Economy: Concepts and Benefits	2	Nil
1.3	Systems Thinking and Life Cycle Perspective	2	Nil
1.4	Role of Electrical Engineers in Driving Sustainability	1	Nil
1.5	Industry 4.0 Enablers for Circular Economy	1	Nil
Module 2: Environmental Impact of Electrical Systems and E-Waste			
2.1	Environmental Impacts of Electrical Energy Systems (Fossil, Nuclear)	2	Nil
2.2	Life Cycle of Electrical Equipment (Transformers, Motors, etc.)	2	Nil
2.3	E-Waste: Sources, Toxicity, Global and National Scenario	2	Nil
2.4	Regulations & Frameworks: EPR, RoHS, WEEE, Indian E-Waste Rules	2	Nil
Module 3: Circular Design in Electrical Engineering			
3.1	Design for Modularity, Repairability, and Disassembly	2	Nil
3.2	Sustainable Materials and Embedded Energy	2	Nil
3.3	Second-life Applications (Batteries, EV Components)	2	Nil
3.4	Circularity in Power Electronics and Control Systems	1	Nil
3.5	Design Case Studies from Electrical Product Industry	1	Nil
Module 4: Sustainable Energy Systems and Smart Grids			
4.1	Overview of Renewable Energy Systems (Solar, Wind, Biomass)	2	Nil
4.2	Role of Energy Storage in Sustainable Systems	1	Nil
4.3	Smart Grids: Concepts, Components, and Circular Features	2	Nil

4.4	Electrification of Transport: EVs and Charging Infrastructure	1	Nil
4.5	Grid Decarbonization and Demand-Side Management	2	Nil
Module 5: Policies, Tools, Standards & Circular Business Models			
5.1	Global & Indian Circular Economy Policies and Roadmaps	2	Nil
5.2	Standards: ISO 14001, LEED, GRIHA, Energy Star	1	Nil
5.3	Life Cycle Assessment (LCA), Carbon Footprint, Material Flow Analysis	2	Nil
5.4	Circular Business Models (Product-as-a-Service, Leasing, Sharing)	2	Nil
5.5	Sustainability Reporting and Circularity Metrics	1	Nil
Total No. of Lecture Hours		**40**	
Total No. of Tutorial Hours			**Nil**

Textbooks:

1. Walter Stahel, **"The Circular Economy: A User's Guide"**, Routledge, 2019.
2. Peter W. Newton et al, **"Transitioning to a Circular Economy,",** CSIRO, 2021.

References:

1. Ellen MacArthur Foundation – ellenmacarthurfoundation.org
2. Kirchherr et al. –*Conceptualizing the Circular Economy*, J. Cleaner Production
3. UNEP – *Sustainable Consumption and Production Handbook*
4. MIT OpenCourseWare – *Environmentally Benign Manufacturing*
5. IEEE Smart Grid resources – https://smartgrid.ieee.org

Course Code: BEE654A
Credits: 3
CIE: 50% Marks
SEE Hours: 3

Course Name: Sensors and Signal Conditioning
L:T:P:S - 3:0:0:0
SEE: 50% Marks
Total Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To equip students to select and characterize sensors for measurement systems 2. To train students in signal conditioning techniques for various sensor types 3. To prepare students to evaluate emerging sensor technologies and IoT applications

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Explain the principle of operation of different sensors and their applications.	Understand
CO2	Discuss the recent trends in sensor technologies.	Understand
CO3	Describe the concept of signal conditioning circuits.	Understand

Mapping with POs and PSOs:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12		PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	1		To be mapped by the respective department		
CO2	3	-	-	-	-	-	-	-	-	-	-	1				
CO3	3	-	-	-	-	-	-	-	-	-	-	1				

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Introduction to sensor-based measurement system		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	General concepts and terminology, sensor classification.	2	Nil
1.2	Material for sensors, micro sensor technology	3	Nil
1.3	Resistive gas sensors, Liquid conductivity sensors	2	
1.4	Selection of sensor.	1	Nil
Module – 2: Reactance variation and Electromagnetic sensors			
2.1	Capacitive Sensors, Inductive Sensors, Electromagnetic Sensors	3	Nil
2.2	Signal Conditioning for Reactance Variation Sensors and Specific Signal Conditioners for Capacitive Sensors	2	Nil
2.3	Industrial applications of electromagnetic sensor	2	Nil
Module – 3: Self-generating sensors			
3.1	Thermoelectric sensors, Piezoelectric sensors	2	Nil
3.2	Pyroelectric sensors, Photovoltaic sensors, Electrochemical sensors.	3	Nil
3.3	Signal conditioning for self-generating sensors and Electrochemical sensors	3	Nil
3.4	Industrial applications of self-generating sensors	1	Nil
Module – 4: Recent developments in sensors			
4.1	Smart sensor, Intelligent sensor	2	Nil
4.2	MEMS sensor, Nano sensors	2	Nil
4.3	Design of smart sensor	2	Nil
4.4	Smart sensor technology for IoT.	2	Nil
4.5	Industrial applications of smart sensor.	1	Nil
Module – 5: Signal Conditioning			
5.1	Concept of signal conditioning, analogue-digital sampling	2	Nil
5.2	Interference, grounding, shielding, minimizing noise.	1	Nil
5.3	Plug in data acquisition board, RS-232 and RS-485 standards	3	Nil

5.4	20mA current loop. IEEE 488 standard.	1	Nil
	Total No. of Lecture Hours	40	
	Total No. of Tutorial Hours		Nil

Textbooks:

1. S Ramón Pallas-Areny, John G. Webster, **"Sensors and Signal Conditioning",** Wiley,2012.
2. Analog Devices Inc. (Norwood, Mass.), **"Practical Design Techniques for Sensor Signal Conditioning",** 1999.

Reference Books:

1. E.O. Doebelin, **"Measurement Systems – Application and Design",** Tata McGraw Hill publishing company, 2019.
2. Patranabis,D, **"Principles of Industrial Instrumentation",** 3rd Edition, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2010.

Course Code: BEE654B **Course Name: Introduction to Electric Vehicle Technology**
Credits: 3 **L:T:P:S - 3:0:0:0**
CIE: 50% Marks **SEE: 50% Marks**
SEE Hours: 3 **Total Marks: 100**

Prerequisites if any	Nil
Learning objectives	1. To develop skills on the modeling of Electric Vehicle dynamics. 2. To familiarise on the operation of power Controllers in Electric Traction Machines. 3. To train applying basics of power converters for developing battery charging systems

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Understand the fundamentals of Electric Vehicles, Battery management systems, battery recycling technologies and Charging stations	Understand
CO2	Model and analyse the dynamics of Electric Vehicles	Analyze
CO3	Understand the basics of electric drives and batteries and apply for EV application.	Apply

Mapping with POs and PSOs:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12		PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	2	-	-	-	-	1		To be mapped by the respective department		
CO2	3	2	2	-	-	2	2	-	-	-	-	1				
CO3	3	-	2	-	-	2	2	-	-	-	-	1				

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Introduction to Electric Vehicles		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Electro mobility and the Environment, History of Electric Vehicle, Types of energy sources for propulsion and emissions.	2	Nil
1.2	Carbon emissions, greenhouse gases and pollutants, Basic architecture of battery and fuel-cell electric vehicles	2	Nil
1.3	Introduction to Electric and Hybrid vehicles: Configuration, Performance and Energy consumption of electric vehicles, Concept and Architecture of Hybrid electric vehicles, economic aspects of EV.	3	Nil
Module – 2: Vehicle Dynamics			
2.1	EV advantage, Efficiency comparison with conventional vehicles, Roadway fundamentals, Laws of motion and vehicle kinetics.	3	Nil
2.2	Vehicle load forces: aerodynamic drag, rolling resistance, grading resistance, Mathematical Model of vehicle to describe vehicle performance,	2	Nil
2.3	Battery Electric Vehicle Range at Constant Speed, Gradability, Vehicle acceleration, Traction motor characteristics, Drive cycles,	3	Nil
	EV Motor Sizing: Rated Vehicle Velocity, Initial Acceleration, Maximum Velocity, Maximum Gradability	2	
Module – 3: Electric drive for EV			
3.1	Basic concept of electric traction, introduction to various electric drive-train topologies.	3	Nil
3.2	Power flow control in electric drive-train topologies	2	Nil
3.3	Overview of EV Technologies: Motor Drive Technology, Energy Source Technology, Battery Charging Technology, Vehicle-to-Grid Technology	3	Nil
Module – 4: Batteries for EV			
4.1	Development Background of the Battery, Principles and Classification of the Lithium-Ion Battery.	2	Nil
4.2	Basic Battery Operation, Battery Parameters, Comparisons of battery technologies	3	Nil
4.3	Charger architectures, EV battery charging system, charger functions, charging	3	Nil

	standards and technologies.		
Module – 5: Battery management, Recycling & charging stations.			
5.1	Battery Management Systems (BMS): Fundamentals of battery management systems and controls	2	Nil
5.2	Battery Recycling Technologies: Technology and economic aspects of battery recycling Battery Applications for Stationary and Secondary Use	2	Nil
5.3	Electric Vehicles charging station: Type of Charging station, Selection and Sizing of charging station, Components of charging station	3	Nil
	Total No. of Lecture Hours	40	
	Total No. of Tutorial Hours		Nil

Textbooks:

1. J Iqbal Hussein, Electric and Hybrid Vehicles: "**Design Fundamentals"**, CRC Press, 2003.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, **"Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design",** CRC Press, 2004
3. Rui Xiong **"Battery Management Algorithm for Electric Vehicles",** Springer Publisher, 2020
4. Gregory L. Plett , **"Battery Management Systems Volume II-Equivalent Circuit Methods"** , ARTECH house,2016

Reference Books:

1. James Larminie, John Lowry**," Electric Vehicle Technology Explained",** Wiley, 2003

Course Code: BEE654C **Course Name: Computer Control of Industrial Process**
Credits: 3 **L:T:P:S - 3:0:0:0**
CIE: 50% Marks **SEE: 50% Marks**
SEE Hours: 3 **Total Marks: 100**

Prerequisites if any	Nil
Learning objectives	1. To describe automatic process control basics. 2. To discuss about the components of automation system. 3. To discuss the digital control concepts and its applications

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Explain the fundamentals of automatic process control	Understand
CO2	Explain the working principles of transducers and understand the components of automation system	Understand
CO3	Understand the distributed digital control and its applications	Understand

Mapping with POs and PSOs:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12		PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	1		To be mapped by the respective department		
CO2	3	-	-	-	-	-	-	-	-	-	-	1				
CO3	3	-	-	-	-	-	-	-	-	-	-	1				

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Introduction to Computer Control		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Expectations from Automation, Basic Functions, Historical Development of Control Systems	2	Nil
1.2	Early Development, Pioneering Period, Direct Digital Control Period, Microcomputer Period	3	Nil
1.3	Current Trends in Computer Control of Process Plants, Centralized Computer Control System, Distributed Control Systems	2	Nil
Module – 2: Fundamentals of Automatic Process Control			
2.1	Introduction, Process Definition, Open Loop Control, Closed Loop Control, Basic Principles of Single Controller Loop, Two-position Control Multi-position Control, PID Control, Proportional Control, Integral Control	2	Nil
2.2	Derivative Control, Proportional Plus Integral Control, Proportional Plus Integral Plus Derivative Control (PID),Controller Operation, Control System Response, Normalized Response, Under damped Response	3	Nil
2.3	Over damped Response, Stability Versus Response, Controllability of Process, Control Loop Tuning, PID Controller Tuning Techniques, Process Reaction Curve Technique, Closed Loop Cycling Technique	3	Nil
Module – 3: Transducers: Present and Future			
3.1	Introduction, Transducer - Definition and Nature, Transducer Functions	2	Nil
3.2	Characteristic of Transducers, Transducer Classification, Technology Trend	3	Nil
3.3	Displacement/Motion Transducers, Linear Variable Differential Transformer (LVDT), Capacitance Gauges, Silicon Displacement Transducers, Fibre - Optic Displacement Transducers, Temperature Transducers	3	Nil
Module – 4: Building Blocks of Automation System			
4.1	Introduction, Processing System, Multi-microprocessor Systems, Microprocessor Interconnections	3	Nil
4.2	Local Area Networks, Analog and Digital I/O Modules, Supervisory Control and Data Acquisition Systems, Remote Terminal Unit	3	Nil
4.3	Reliable System Development Strategy- Causes of System Failure, Fail-Safe System, Fault-Tolerant System, Graceful Degradation Systems, Lockstep System	2	Nil

	Concept, Dual Modular Redundancy.		
Module – 5: Distributed Digital Control			
5.1	Introduction, Functional Requirements of (Distributed) Process Control System, System Architecture.	3	Nil
5.2	Distributed Control Systems, Some Popular Distributed Control Systems, Fieldbus System	3	Nil
5.3	LonWorks: Control Network Technology on a Chip, LonWorks Technology, Applications.	3	Nil
	Total No. of Lecture Hours	40	
	Total No. of Tutorial Hours		Nil

Textbooks:

1. Krishna Kant, **"Computer based Industrial Control",** 2nd edition, Khanna Publishers.
2. S. K. Bhattacharya, Brijnder Singh, **"Control of Machines"**, 2nd edition, New Age International Publisher, 2006.

Reference Books:

1. Hugh Jack, ***"Automating manufacturing systems with PLCs"***, Version 4.6
2. Mini S. Thomas, John D. McDonald, ***"Power System SCADA and Smart Grids"***, CRC Press

Course Code: BEE654D
Credits: 3
CIE: 50% Marks
SEE Hours: 3

Course Name: Optimization Techniques
L:T:P:S - 3:0:0:0
SEE: 50% Marks
Total Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To equip students to formulate and solve LP problems using simplex methods 2. To train students in classical and modern optimization techniques 3. To prepare students to apply optimization methods to engineering problems 4. To demonstrate the implementation of algorithms for constrained/unconstrained problems

Course Outcomes:

On the successful completion of the course, the student will be able to

COs		Bloom's level
CO1	Formulate Linear Programming Problem in standard form and solve the same using different algorithms.	Apply
CO2	Solve single variable optimization problem and multivariable optimization problem using classical techniques.	Apply
CO3	Solve unconstrained nonlinear programming problem using different techniques.	Apply

Mapping with POs and PSOs:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12		PSO1	PSO2	PSO3
CO1	3	2	2	-	-	-	-	-	-	-	-	-		To be mapped by the respective department		
CO2	3	2	2	-	-	-	-	-	-	-	-	-				
CO3	3	2	2	-	-	-	-	-	-	-	-	-				

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Linear Programming-1		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Simplex method, standard form of LPP	2	Nil
1.2	Geometry of LPP, definitions and theorems	2	Nil
1.3	Simplex algorithm, two phase simplex method, Engineering applications of optimization	3	Nil
Module – 2: Linear Programming-2			
2.1	Revised simplex method	2	Nil
2.2	Duality in LP	2	Nil
2.3	Dual simplex method, Statement of optimization problem.	3	Nil
Module – 3: Classical Optimization Techniques			
3.1	Single variable optimization, multivariable optimization with no constraints, multivariable optimization with equality constraints – solution by the method of Lagrange multipliers	4	Nil
3.2	multivariable optimization with inequality constraints, Kuhn – Tucker conditions, Classification of optimization problems	4	Nil
Module – 4: Unconstrained Non-linear programming 1			
4.1	Introduction, classification of unconstrained minimization methods,	3	Nil
4.2	General approach, rate of convergence, scaling of design variables, gradient of a function,	3	Nil
4.3	Steepest descent method (Cauchy), conjugate gradient method (Fletcher-Reeves), Selection of design variables.	3	Nil
Module – 5: Unconstrained Non-linear programming-2			
5.1	Newton's method, Quasi Newton method,	4	Nil
5.2	Davidson -Fletcher- Powell method, Applications of Newton's method	5	Nil
	Total No. of Lecture Hours	**40**	
	Total No. of Tutorial Hours		**Nil**

Textbooks:

1. S. S. Rao, **"Engineering Optimization – Theory and practice",** 3rd enlarged edition, New age international publishers, 2010.
2. Misra Shashikant, Bhagwat Ram, **"Introduction to Linear Programming with MATLAB",** Chapman & hall (CRC Press), 2017

Reference Books:

1. Hamdy .A. Taha, **"Operations Research – An Introduction",** 6th edition, PHI.
2. S.D. Sharma, **"Operations Research"**,Kedarnath Ramnath and Co, 13th edition
3. Winker, Peter, Optimization Heuristics in Econometrics: **"Applications of Threshold Accepting"**, John Wiley & Sons, 2000
4. Kalyanmoy Deb, **"Optimization for Engineering Design-Algorithms and Examples",** Prentice Hall India1998

Course Code: BEE654E
Credits: 3
CIE: 50% Marks
SEE Hours: 3

Course Name: Industrial Automation
L:T:P:S - 3:0:0:0
SEE: 50% Marks
Total Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To familiarise the operation of control circuit components 2. To develop fundamental programming skills using PLC 3. To train the students to analyze the performance of various building blocks in automation through SCADA

Course Outcomes:

On the successful completion of the course, the student will be able to

Cos		**Bloom's level**
CO1	Understand automation process control and analyze the operation of control circuit components, industrial control	Understand
CO2	Apply the concept of ladder logic and its relationship in PLC Programming	Apply
CO3	Analyze the performance of various building blocks in automation through SCADA, IEDs	Analyse

Mapping with POs and PSOs:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12		PSO1	PSO2	PSO3
CO1	3	3	-	-	3	2	-	-	-	-	-	1		To be mapped by the respective department		
CO2	3	3	2	-	3	2	-	-	-	-	-	1				
CO3	3	3	2	-	3	2	-	-	-	-	-	1				

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Fundamentals of Automatic Process Control		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Introduction, Process Definition, Open Loop Control, Close Loop Control	3	Nil
1.2	Basic Principles of Single Controller Loop, Two-position Control, Multi-position Control, PID Control	3	Nil
Module – 2: Programmable Logic controllers			
2.1	Controllers, Hardware, Internal Architecture, PLC systems Problems, Input devices, Output devices	2	Nil
2.2	Examples of applications, Problems	2	Nil
2.3	Input/output units, Signal conditioning, Remote connections, Networks, Processing inputs, I/O addresses Problems	4	Nil
Module – 3: Ladder and functional block programming			
3.1	Ladder diagrams, Logic functions, Latching, Multiple outputs	2	Nil
3.2	Entering programs, Function blocks, Program examples, Problems	2	Nil
3.3	Intraction lists, Sequential function charts, Structured text Problems	2	Nil
3.4	Internal relays, Ladder programs, Battery-backed relays, One-shot operation, Set and reset	2	Nil
3.5	Master control relay Problems	2	Nil
Module – 4: Power System Automation			
4.1	Evolution of automation systems, Open system: Need and advantages, Building blocks of SCADA systems	2	Nil
4.3	Remote terminal unit (RTU), Evolution of RTUs, Components, Communication subsystem, Logic subsystem, Termination subsystem,	4	Nil
4.4	Testing and human-machine interface (HMI) subsystem, Power supplies, Advanced RTU functionalities	2	Nil
Module – 5: Intelligent Electronic Devices (IEDs)			
5.1	IED functional block diagram, Hardware and software architecture of the IED	3	Nil

5.2	IED communication subsystem, IED advanced functionalities, Tools for settings, commissioning, and testing, Programmable LCD display, Typical IEDs	5	Nil
	Total No. of Lecture Hours	40	
	Total No. of Tutorial Hours		Nil

Textbooks:

1. W. Bolten, ***"Programming Logic Controllers"***, Elsevier Publication, Oxford UK.
2. Mini S. Thomas, John D. McDonald, ***"Power System SCADA and Smart Grids"***, CRC Press

Reference Books:

1. S. K. Bhattacharya, Brijnder Singh, ***"Control of Machines"***, 2nd edition, New Age International Publisher, 2006.

Course Code: BEE654F
Credits: 3
CIE: 50% Marks
SEE Hours: 3

Course Name: Industry 4.0
L:T:P:S - 3:0:0:0
SEE: 50% Marks
Total Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To impart basic idea in Industry 4.0. 2. To provide students with good depth of knowledge of designing Industrial 4.0 Systems for various application 3. To learn the design of Industry 4.0 systems for Energy and smart vehicular applications

Course Outcomes:

On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Explain the applications of Industry 4.0	Understand
CO2	Apply Industry 4.0 for energy and smart vehicular applications	Apply

Mapping with POs and PSOs:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12		PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	-		To be mapped by Respective Department		
CO2	3	3	-	-	-	-	-	-	-	-	-	-				

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Introduction to Industry 4.0		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Introduction, Historical Context, General framework, Application areas, Dissemination of Industry 4.0 and the disciplines that contribute to its development, Artificial intelligence,	4	Nil
1.2	The Internet of Things and Industrial Internet of Things, Additive manufacturing, Robotization and automation, Current situation of Industry 4.0	2	Nil
1.3	Introduction to Industry 4.0 to Industry 5.0 Advances	2	Nil
Module – 2: Industry 4.0 And Cyber Physical System.			
2.1	Introduction to Cyber Physical Systems (CPS), Architecture of CPS	3	Nil
2.2	Components, Data science and technology for CPS, Emerging applications in CPS in different fields	2	Nil
2.3	Case study: Application of CPS in health care domain.	3	Nil
Module – 3: Smart Energy Sources			
3.1	Energy Storage for Mitigating the Variability of Renewable Electricity Sources-Types of electric energy storage	3	Nil
3.2	Potential of Sodium-Sulfur Battery Energy Storage to Enable Integration of Wind-Case study	2	Nil
3.3	Electric Vehicles as Energy Storage: V2G Capacity Estimation.	2	Nil
Module – 4: Smart Grid			
4.1	Smart grid definition and development Smart Grid	3	Nil
4.2	Understanding the Smart Grid, Smart grid solutions	3	Nil
4.3	Design challenges of smart grid and Industry 4.0.	2	Nil
Module – 5: Smart Applications			
5.1	Understanding Smart Appliances -Smart Operation-Smart Monitoring	3	Nil
5.2	Smart Energy Savings-Smart Maintenance, Case study	2	Nil
5.3	Smart Cars, Self-Driving Cars, Introducing Google's Self-Driving Car, Intellectual Property Rights.	4	Nil
	Total No. of Lecture Hours	40	
	Total No. of Tutorial Hours		Nil

Reference Books:

1. Jean-Claude André, **"Industry 4.0",** Wiley- ISTE, July 2019, ISBN: 781786304827,2019.
2. Diego Galar Pascual, Pasquale Daponte, Uday Kumar, **"Handbook of Industry 4.0 and SMART Systems"** Taylor and Francis,2020
3. Miller M, **"The internet of things: How smart TVs, smart cars, smart homes, and smart cities are changing the world",** Pearson Education, 2015, ISBN: 9780134021300.
4. Pengwei Du and Ning Lu, **"Energy storage for smart grids: planning and operation for renewable and variable energy resources VERs"**, Academic Press, 2018, Reprint edition , ISBN-13:978-0128100714
5. Hossam A. Gabbar, **"Smart Energy Grid Engineering",** Academic Press, 2017, ISBN 978- 0-12-805343-0.
6. Mini S. Thomas, John Douglas McDonald, **"Power System SCADA and Smart Grids",** CRC Press, 2017

Course Code: BEEL657A
Credits: 1
CIE: 100% Marks
SEE Hours: -

Course Name: PCB Design and Fabrication
L:T:P:S - 0:0:2:0
SEE: -
Total Marks: 100

Prerequisites if any	Nil
Learning objectives	1. To train students in schematic capture 2. To teach students PCB layout techniques 3. To prepare students for multilayer board design

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Design of PCB for different electronic circuits using ORCAD/KiCAD software	Apply

Mapping with POs and PSOs:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12		PSO1	PSO2	PSO3
CO1	3	3	3	-	3	3	3	3	3	3	-	3		3	3	3

Mapping Strength: Strong– 3 Medium – 2 Low – 1

List of Experiments:

Sl. No.	**Experiment**	**Hands on/ Virtual**
1	Introduction to ORCAD/KiCAD software (Initialization of new project, Exploring various features)	Hands on
2	Creating the circuit schematics using Capture module	Hands on
3	Understanding the aspects associated with layout (track, net via and their usage)	Hands on
4	Preparation of schematics of circuits consisting of Digital ICs, Resistors, connectors	Hands on
5	Preparation of schematics of circuits consisting of Linear ICs, Resistors, capacitors	Hands on
6	Foot print creation of electronic components	Hands on
7	Preparation of schematics of circuits consisting of Power semiconductors / SPM, Current/voltage sensors, capacitors, regulators etc.	Hands on
8	Printed circuit board design	Hands on
9	Placements components on PCB: Thermal management, EMI/EMC considerations	Hands on
10	Introduction to routing on PCB	Hands on
11	Design and routing for multilayer PCBs and usage of PCB in modern days.	Hands on

Course Code: BEEL657B **Course Name: Energy Audit, Management and Conservation**
Credits: 1 **L:T:P:S - 1:0:0:0**
CIE: 100% Marks **SEE: -**
SEE Hours: - **Total Marks: 100**

Prerequisites if any	Nil
Learning objectives	1. To familiarise different terms & principles of energy conservation, audit and management. 2. To demonstrate energy audit and prepare reports. 3. To introduce efficient electricity utilization, saving and recovery in different electrical systems.

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Explain the fundamental concepts of energy audit, management and conservation	Understand
CO2	Conduct energy audit and prepare reports	Apply

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Energy Scenario		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	Classification of Energy, Indian energy scenario, Sectoral energy consumption (domestic, industrial and other sectors), energy needs of growing economy, energy intensity, long term energy scenario	2	Nil
1.2	Energy pricing, energy security, energy conservation and its importance, energy strategy for the future. Energy conservation Act 2001 and its features	2	Nil
1.3	Schemes of Bureau of Energy Efficiency (BEE) including Designated consumers, Integrated energy policy, National action plan on climate change.	1	Nil
Module – 2: Energy Management & Audit			
2.1	Definition, energy audit, need, types of energy audit, energy audit instruments and metering	2	Nil
2.2	Energy management (audit) approach - understanding energy costs, Benchmarking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements, fuel and energy substitution	2	Nil
2.3	ECO assessment and Economic methods-specific energy analysis-Minimum energy paths, Roles and responsibilities of a certified Energy Auditor	1	Nil
Module – 3: Energy and environment, air pollution, climate change			
3.1	Energy conservation measures - Electric loads of Air conditioning & Refrigeration	1	Nil
3.2	Energy conservation measures- Electric water heating- Geysers- Solar Water Heaters	2	Nil
3.3	United Nations Framework Convention on Climate Change (UNFCC), sustainable development, Kyoto Protocol, Clean Development Mechanism (CDM), CDM Procedures case of CDM – Bachat Lamp Yojna and industry; Prototype Carbon Fund (PCF).	2	Nil
	Total No. of Lecture Hours	15	
	Total No. of Tutorial Hours		Nil

Reference Books:

1. Dale R Patrick, Stephen W Fardo, "Energy Conservation Guidebook", 2nd Edition, CRC Press.
2. Albert Thumann, "Handbook of Energy Audits", 6th Edition, The Fairmont Press
3. "Bureau of Energy Efficiency", Reference book: No.1, 2, 3 4

Course Code: BEEL657C **Course Name: Design of Control Systems**
Credits: 1 **L:T:P:S - 0:0:2:0**
CIE: 100% Marks **SEE: -**
SEE Hours: - **Total Marks: 100**

Prerequisites if any	Nil
Learning objectives	1. To teach students state-space methods 2. To train students in controller design 3. To prepare students for observer implementation

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Design compensators and obtain the characteristics	Apply
CO2	Construct state space models of physical systems and apply different techniques to solve the state equations.	Apply
CO3	Design state variable feedback controllers and state observers.	Apply

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

List of Experiments:

Sl. No.	**Experiment**	**Hands on/ Virtual**
1	Design of Lag compensator and to obtain the characteristics by experiment and simulation using MATLAB	Hands on
2	Design of Lead compensator and to obtain the characteristics by experiment and simulation using MATLAB	Hands on
3	Design of Lead-Lag compensators and to obtain the characteristics by experiment and simulation using MATLAB	Hands on
4	Design of PID controllers using the Root-locus diagrams	Hands on
5	Design of P, PI, PD and PID controllers using the Bode diagrams	Hands on
6	Implementation of state models for linear continuous-time systems in MATLAB	Hands on
7	State space representation using physical and phase variables and solution of state equations using MATLAB	Hands on
8	Design of state observer and analysis of the effects of the addition of the observer on a closed-loop system using MATLAB	Hands on
9	Design of regulator with observer and analysis using MATLAB	Hands on
10	Design of control system with observer and analysis using MATLAB	Hands on

Reference Books:

1. Katsuhiko Ogata,"**Modern Control Engineering**",3rd edition, Prentice Hall of India.
2. J. Nagrathand M. Gopal,"**Control Systems Engineering**", 5th edition, New Age International (P) Ltd.

Course Code: BEEL657D **Course Name: Green Fuels and Environment**
Credits: 1 **L:T:P:S - 1:0:0:0**
CIE: 100% Marks **SEE: -**
SEE Hours: - **Total Marks: 100**

Prerequisites if any	Nil
Learning objectives	1. To equip students to critically assess human-environment interactions 2. To train students in evaluating green technologies and their implementations 3. To demonstrate practical applications of environmental protection methods 4. To prepare students to propose innovative solutions for sustainability challenges

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Discuss the relation between humans and environment	Understand
CO2	Apply the green fuel technologies and its impact on environment	Apply
CO3	Apply novel methods for sustainable development	Apply

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

Module – 1: Humans and Environment		**No. of Lecture Hours**	**No. of Tutorial Hours**
1.1	what are we doing, scalability of our habits, are we innovating enough, issues that we are overlooking	2	Nil
1.2	what we should be doing, how to manage our waste, pollution and its implications, waste to energy**,** our innovations are our future, Technologies to dispose e-waste	3	Nil
Module – 2: Green fuels and its significance			
2.1	Understand fuels, green fuels	2	Nil
2.2	Alternate energy sources and the cost to future, Novel technologies and the path forward, Innovative ideas to reduce carbon footprint	3	Nil
Module – 3: Protectors of the Earth			
3.1	Understanding microbes and its uses, harmful vs beneficial microbes, using microbes for solving our problems, industrial applications	3	Nil
3.2	Technology of bio gas plants	2	Nil
	Total No. of Lecture Hours	15	
	Total No. of Tutorial Hours		Nil

Textbooks:

1. Basanta Kumara Behera and Ram Prasad, **"Environmental Technology and Sustainability",** 1st Edition, by, Elsevier
2. Maulin Shah, **"Removal of Toxic Pollutants through Microbiological and Tertiary Treatment",** 1st Edition, Elsevier

Reference Books:

1. Ashok Pandey, Christian Larroche, Edgard Gnansounou, "**Biofuels: Alternative Feedstocks and Conversion Processes**", Academic Press
2. Rajesh Prasad Rastogi, Datta Madamwar and Ashok Pandey, "Algal Green Chemistry Recent Progress in Biotechnology", Elsevier

Course Code: BEEL657E **Course Name: Object Oriented Programming with C++**
Credits: 1 **L:T:P:S - 0:0:2:0**
CIE: 100% Marks **SEE: -**
SEE Hours: - **Total Marks: 100**

Prerequisites if any	Nil
Learning objectives	1. To emphasize the importance of Classes, Objects & Data Abstraction 2. To train the students to implement encapsulation, Overloading, Inheritance, Polymorphism Reusability & Exception Handling

Course Outcomes:
On the successful completion of the course, the student will be able to

COs		**Bloom's level**
CO1	Apply the major object-oriented concepts to implement object	Apply
CO2	Apply advanced features of C++ specifically stream I/O, templates and operator overloading	Apply

Mapping with POs and PSOs:

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

Mapping Strength: Strong– 3 Medium – 2 Low – 1

List of Experiments:

Sl. No.	**Experiment**	**Hands on/ Virtual**
1	Write a program that uses a class where the member functions are defined inside a class	Hands on
2	Write a program that uses a class where the member functions are defined outside a class	Hands on
3	Write a program to demonstrate the use of static data members	Hands on
4	Write a program to demonstrate the use of constant data members.	Hands on
5	Write a program to demonstrate the use of zero argument and parameterized constructors.	Hands on
6	Write a program to demonstrate the use of dynamic constructor.	Hands on
7	Write a program to demonstrate the use of explicit constructor	Hands on
8	Write a program to demonstrate the use of initializer list	Hands on
9	Write a program to demonstrate the overloading of increment and decrement operators	Hands on
10	Write a program to demonstrate the multilevel inheritance.	Hands on

Textbooks:

1. SouravSahay**, "Object-Oriented Programming with C++",** Oxford University Press, 2006

Reference Books:

1. B JarneStroustrup, "**The C++ program language**", Pearson Education Asia
2. Stanley B. Lippman, JoseeLajoie, Barbara E. Moo, "**C++ Primer**", 4th Edition, Addison Wesley, 2005