KAMARAJ COLLEGE OF ENGINEERING & TECHNOLOGY

(An Autonomous Institution - AFFILIATED TO ANNA UNIVERSITY, CHENNAI)

S.P.G.Chidambara Nadar - C.Nagammal Campus

S.P.G.C. Nagar, K.Vellakulam – 625 701 (Near VIRUDHUNAGAR).

B.E. ELECTRICAL AND ELECTRONICS ENGINEERING
REGULATIONS – 2021
AUTONOMOUS SYLLABUS
CHOICE BASED CREDIT SYSTEM
V TO VI SEMESTER CURRICULUM AND SYLLABI

VISION:

To make the Department of Electrical and Electronics Engineering of this Institution the unique of its kind in the field of Research and Development activities in this part of the world.

MISSION:

Department of Electrical and Electronics Engineering is committed to impart highly innovative and technical knowledge in the field of Electrical and Electronics Engineering to the urban and unreachable rural student folks through Total Quality Education

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

PEO 1: **Technical Knowledge:** To provide basic knowledge in Physics, Chemistry, Mathematics and necessary foundation in various concepts of Electrical and Electronics Engineering

PEO 2: **Problem Solving:** To impart training to enable the students to envisage the real time problems related to the field of Electrical and Electronics Engineering and allied areas faced by the Industries so as to model, analyze and provide appropriate solutions.

PEO 3: **Personality Development:** To provide an academic environment for the students to develop team spirit, leadership qualities, communication skills and soft skills.

PEO 4: **Life Long Learning:** To motivate students to prepare for competitive examinations enabling them to pursue higher studies, thereby, promoting Research and Development activities.

PROGRAM OUTCOMES:

After going through the four years of study, the Electrical and Electronics Engineering graduates will have the ability to

POs	Graduate Attribute	Programme Outcome
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 analyze 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 thespecified 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

POs	Graduate Attribute	Programme Outcome
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 team work	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 (PSOs):

PSO1 : Ability to design and solve engineering problems by applying the fundamental knowledge of Engineering Mathematics, Basic Sciences, Electrical and Electronics Engineering.

PSO2 : Ability to understand the recent technological developments in Electrical & Electronics Engineering and develop products / software to cater the Societal & Industrial needs.

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REGULATIONS - 2021

CHOICE BASED CREDIT SYSTEM

B.E. ELECTRICAL AND ELECTRONICS ENGINEERING

CURRICULUM AND SYLLABI FOR SEMESTER V TO VI

SEMESTER V

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	EE2301	AC Machines	PC	3	3	0	0	3
2.	EE2302	Microprocessors and Microcontrollers	PC	3	3	0	0	3
3.	EE2303	Protection and Switchgear	PC	3	3	0	0	3
4.		Professional Elective I	PE	3	3	0	0	3
5.		Professional Elective II	PE	3	3	0	0	3
6.		Professional Elective III	PE	3	3	0	0	3
PRACTICAL								
7.	EE2304	AC Machines Laboratory	PC	4	0	0	4	2
8.	EE2305	Microprocessors and Microcontrollers Laboratory	PC	4	0	0	4	2
9.	EM2351	Professional Communication	EM	2	0	0	2	1
10.	EM2301	Internship**	EM	0	0	0	0	1
			TOTAL	**28**	**18**	**0**	**10**	**24**

**** Credits earned by the student through internship will be given in the final consolidated mark statement.**

SEMESTER VI

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	EE2351	Power Electronics	PC	3	3	0	0	3
2.	EE2352	Power System Operation and Control	PC	3	3	0	0	3
3.		Professional Elective IV	PE	3	3	0	0	3
4.		Professional Elective V	PE	3	3	0	0	3
5.		Professional Elective VI	PE	3	3	0	0	3
6.		Open Elective I	OE	4	2	0	2	3
PRACTICAL								
7.	EE2353	Mini Project	EM	3	0	0	3	1
8.	EE2354	Power Electronics Laboratory	PC	4	0	0	4	2
9.	EE2355	Power System Simulation Laboratory	PC	4	0	0	4	2
			TOTAL	**30**	**17**	**0**	**13**	**23**

Verticals: PE & Honours

Vertical 1	Vertical 2	Vertical 3
Renewable Energy	**Converters and Drives**	**Smart Grid**
Power Plant Engineering	Special Electrical Machines	Distributed Generation and Microgrid
Utilization and Conservation of Electrical Energy	Solid State Drives	Smart Grid Technologies
Solar Photovoltaic System	Modern Power Converters	Soft Computing Techniques
Wind Energy Conversion System	Design of Electrical Machines	Power Quality
Power Electronics for Renewable Energy Systems	Hybrid Electric Vehicle	High Voltage Engineering
Energy Storage Technologies	Electric Vehicles and Energy Management	PLC and SCADA
Design, Installation and Commissioning of Renewable Energy Systems	Design of Electrical Vehicle Charging System	Digital Signal Processing

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	VEE311	Power Plant Engineering	PE	3	3	0	0	3
2.	VEE312	Utilization and Conservation of Electrical Energy	PE	3	3	0	0	3
3.	VEE313	Solar Photovoltaic System	PE	3	3	0	0	3
4.	VEE314	Wind Energy Conversion System	PE	3	3	0	0	3
5.	VEE315	Power Electronics for Renewable Energy Systems	PE	3	3	0	0	3
6.	VEE316	Energy Storage Technologies	PE	3	3	0	0	3
7.	VEE317	Design, Installation and Commissioning of Renewable Energy Systems	PE	3	3	0	0	3

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	VEE321	Special Electrical Machines	PE	3	3	0	0	3
2.	VEE322	Solid State Drives	PE	3	3	0	0	3
3.	VEE323	Modern Power Converters	PE	3	3	0	0	3
4.	VEE324	Design of Electrical Machines	PE	3	3	0	0	3
5.	VEE325	Hybrid Electric Vehicle	PE	3	3	0	0	3
6.	VEE326	Electric Vehicles and Energy Management	PE	3	3	0	0	3
7.	VEE327	Design of Electrical Vehicle Charging System	PE	3	3	0	0	3

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	VEE331	Distributed Generation and Microgrid	PE	3	3	0	0	3
2.	VEE332	Smart Grid Technologies	PE	3	3	0	0	3
3.	VEE333	Soft Computing Techniques	PE	3	3	0	0	3
4.	VEE334	Power Quality	PE	3	3	0	0	3
5.	VEE335	High Voltage Engineering	PE	3	3	0	0	3
6.	VEE336	PLC and SCADA	PE	3	3	0	0	3
7.	VEE337	Digital Signal Processing	PE	3	3	0	0	3

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MEE101	Battery Management System	OE	3	3	0	0	3
2.	MEE102	Electric Vehicle Technologies	OE	3	3	0	0	3
3.	MEE103	Green Energy Technologies	OE	3	3	0	0	3
4.	MEE104	DC and AC Microgrid	OE	3	3	0	0	3
5.	MEE105	Energy Management and Auditing	OE	3	3	0	0	3
6.	MEE106	Sensors and Instrumentation	OE	3	3	0	0	3

Open Elective I

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	OEE781	Renewable Energy Sources	OE	3	3	0	0	3

Course Code	Course Name	L	T	P	C
EE2301	**AC MACHINES**	**3**	**0**	**0**	**3**

Category: Professional Core

a. Preamble

This course elaborates the construction and performance of synchronous and induction machines. It describes the speed control of three-phase induction motors and performance of special machines.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the construction, types, parallel operation and determination of voltage regulation of synchronous generator.	K2
CO2	Explain the operating principle, construction and performance characteristics of Synchronous motor.	K2
CO3	Make use of three-phase Induction motor to understand its construction, working principle, types and characteristics.	K3
CO4	Illustrate the various types of starting and speed control methods in three phase Induction motor.	K3
CO5	Summarize the operating principle of Single phase Induction motor and special machines suitable for real time applications.	K2

c. Course Syllabus **Total : 45 Periods**

SYNCHRONOUS GENERATOR **9**

Constructional details – Types of rotors –winding factors- emf equation – Synchronous reactance – Armature reaction – Synchronizing and parallel operation – Synchronizing torque - Change of excitation and mechanical input- Voltage regulation – EMF, MMF and ZPF methods

SYNCHRONOUS MOTOR **9**

Principle of operation – Torque equation – Operation on infinite bus bars - V and Inverted V curves – Power input and power developed equations – Starting methods – Hunting – damper windings - Synchronous condenser.

THREE PHASE INDUCTION MOTOR **9**

Constructional details – Types of rotors –- Principle of operation – Slip –cogging andcrawling- Equivalent circuit – Torque-Slip characteristics - Condition for maximum torque – Losses and efficiency – Load test - No load and blocked rotor tests - Circle diagram – Separation of losses – Double cage induction motors –Induction generators

STARTING AND SPEED CONTROL OF THREE PHASE INDUCTION MOTOR **9**

Need for starters – Types of starters – DOL, Rotor resistance, Autotransformer and Star- delta starters – Speed control – Voltage control, Frequency control and V/f control – Slip power recovery scheme.

SINGLE PHASE INDUCTION MOTORS AND SPECIAL MACHINES **9**

Constructional details of single phase induction motor – Double field revolving theory – Equivalent circuit – No load and blocked rotor test – Performance analysis – Starting methods of single-phase induction motors – Capacitor-start capacitor run Induction motor- Construction and working principle of : BLDC motor, Universal motor, Stepper motors.

d. Activities

Students shall be exposed to the different types of AC machines and special machines available in the college premises.

e. Learning Resources

Text Books

1. A.E. Fitzgerald, Charles Kingsley, Stephen. D. Umans, *Electric Machinery*, Mc Graw Hill, 2003.
2. Stephen J. Chapman, *Electric Machinery Fundamentals*, 4th Edition, McGraw Hill, 2010.

Reference Books

1. Gupta, J.B, *Theory & performance of electrical machines*, SK Kataria and Sons, 2014.
2. Del Toro, V, *Basic electric machines*. Pearson India Education, 2016.
3. P.S. Bhimbhra, *Electrical Machinery*, Khanna Publishers, 2003.
4. D.P. Kothari and I.J. Nagrath, *Electric Machines*, 5th Edition, McGraw Hill, 2018.
5. Vedam Subrahmaniam, *Electric Drives (Concepts and Applications),* Tata McGraw-Hill, 2010.

Course Code	Course Name	L	T	P	C
EE2302	**MICROPROCESSORS AND MICROCONTROLLERS**	**3**	**0**	**0**	**3**

Category: Foundation Course (Engineering Science)

a. Preamble

This course introduces the assembly language programming in basic microprocessors and microcontrollers. It describes the architecture and applications of 8085, 8051, Arduino and PIC microcontroller.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the functional blocks of 8085, machine cycles and write the assembly language program in 8085.	K2
CO2	Explain the basic functional blocks of 8051 and applications of 8051.	K2
CO3	Develop the microprocessorbased system with peripheral interfacing devices.	K3
CO4	Apply the concepts of Arduino in its applications	K3
CO5	Illustrate the concept of interrupt, timer and I/O programming using PIC instruction set.	K3

c. Course Syllabus **Total : 45 Periods**

8085 MICROPROCESSOR **9**

Functional block diagram – Timing Diagram – Interrupt structure- Instruction format and addressing modes – Assembly language format – Data transfer, data manipulation & control instructions-Simple programming

8051 MICROCONTROLLER **9**

Functional block diagram- SFR-RAM addressing-Timer-Ports-Interrupt structure-Instruction Set-Stepper and Servo Motor control

INTERFACING BASICS AND ICS **9**

Study of Architecture and programming of ICs: 8255 PPI, 8259PIC, 8279 Keyboard display controller and 8254 Timer/Counter

ARDUINO **9**

Pin Configuration-Data types-Operators- Conditional and Looping Statements- Distance measurement-Temperature Measurement- Object Detection

INTRODUCTION TO RISC BASED ARCHITECTURE **9**

PIC16 /18 architecture, Memory organization – Addressing modes – Instruction set - Programming techniques – Timers – I/O ports – Interrupt programming.

d. Activities

Students shall be exposed to IDE and have to complete a mini-project using microprocessors or microcontrollers development board.

e. Learning Resources

Text Books

1. Ramesh S. Gaonkar, *Microprocessor Architecture Programming and Application,* Pen ram International (P) ltd., Mumbai, 6th Edition, 2019.
2. Muhammad Ali Mazidi & Janice Gilli Mazidi, *The 8051 Micro Controller and Embedded Systems*, Pearson Education, Second Edition, 2011.
3. Muhammad Ali Mazidi & Janice Gilli Mazidi, *The PIC Micro Controller and Embedded Systems*, Pearson Education, 2010.

Reference Books

1. Douglas V. Hall, *Microprocessors & Interfacing*, Tata McGraw Hill 3rd Edition,2017.
2. Krishna Kant, *Microprocessors & Microcontrollers*, Prentice Hall of India, 2007.

3 Michael Margolis, *Arduino Cookbook*, O’Reilly, 2011.

4 Kenneth Ayala, *The 8051 Microcontroller*, Thomson, 3rd Edition, 2004.

Course Code	Course Name	L	T	P	C
EE2303	**PROTECTION AND SWITCHGEAR**	**3**	**0**	**0**	**3**

Category: Professional core

a. Preamble

This course introduces the various protection schemes (relays and circuit breakers) for different power system apparatus.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the causes and effects of different types of faults and need for protection schemes.	K2
CO2	Explain the basic principle, construction and characteristics of different electromagnetic relays.	K2
CO3	Apply the protection schemes used for transformer, generator, motor, bus bar and transmission line.	K3
CO4	Demonstrate the static relays and various numerical protection schemes.	K2
CO5	Illustrate the principle, construction, selection and problems associated with different types of circuit breaker.	K2

c. Course Syllabus **Total : 45 Periods**

PROTECTION SCHEMES **9**

Principles and need for protection schemes – causes and types of faults – Methods of Grounding - Zones of protection and essential qualities of protection – Protection schemes - Current transformers and Potential transformers and their applications in protection schemes

ELECTROMAGNETIC RELAYS **9**

Operating principles of relays - the Universal relay – Torque equation – R-X diagram – Electromagnetic Relays – Over current, Directional, Distance, Differential, Negative sequence and Under frequency relays.

APPARATUS PROTECTION **9**

Transformer protection: Differential Protection - Buchholz Relay - Generator protection: Stator and Rotor protection – loss of excitation and loss of prime mover - Motor protection: Electrical faults - Bus bar protection: Differential protection - Transmission line – Three stepped distance protection.

STATIC RELAYS AND NUMERICAL PROTECTION 9

Static relays – Phase, Amplitude Comparators – Synthesis of various relays using Static comparators – Block diagram of Numerical relays – Over current protection, transformer differential protection, distance protection of transmission lines.

CIRCUIT BREAKERS 9

Physics of arcing phenomenon and arc interruption - re-striking voltage and recovery voltage - rate of rise of recovery voltage - resistance switching – current chopping - interruption of capacitive current - Types of circuit breakers – air blast, oil, vaccum, SF6, MCBs, ELCB, MCCBs – comparison of different circuit breakers.

d. Activities

Students shall be exposed to the basic protection schemes and modern technologies incorporated in the protection system.

e. Learning Resources

Text Books

1. Paithankar, Y.G. and Bhide, S.R.,*Fundamentals of power system protection*, PHI Learning Pvt. Ltd, 2011.
2. Ram, B., *Power system protection and switchgear,* Tata McGraw-Hill Education, 2011.

Reference Books

1. Rao, S.S.,*Switchgear and Protection: Theory, Practice and Solved Problems*, Khanna publishers, 1982.
2. Ravindranath, B. and Chander, M., *Power system protection and switchgear*, New Age International, 1977.
3. Chakrabarti, A., Soni, M.L., Gupta, P.V. and Bhatnagar, U.S., *A text book on Power System Engineering,* Dhanpar Rai and Co.(P) Ltd, 2000.
4. Mehta, V.K. and Mehta, R., *Principles of power systems*, S. Chand, New Delhi, India, 2011.

5 Wadhwa, C.L.. *Electrical power systems*, New Age International, 2006.

Course Code	Course Name	L	T	P	C
EE2304	**AC MACHINES LABORATORY**	**0**	**0**	**4**	**2**

Category: Professional Core

a. Preamble

This course introduces the determination of regulation for three-phase alternator by various methods and also different performance characteristics of synchronous & induction machines.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Infer the performance characteristics of three-phase salient pole alternator to determine the voltage regulation using appropriate method.	K4
CO2	Experiment with three-Phase Synchronous Motor and evaluate its performance characteristics.	K3
CO3	Show the performance characteristics of three-phase slip-ring and squirrel cage Induction Motor.	K3
CO4	Demonstrate the performance of three-phase Induction Motor by conducting load test.	K3
CO5	Model the equivalent circuit of single-phase induction motor using suitable test.	K3

c. Course Syllabus **Total : 60 Periods**

1. Regulation of three-phase alternator by EMF method.
2. Regulation of three-phase alternator by MMF method.
3. Regulation of three-phase alternator by ZPF method.
4. V and Inverted V curves of Three Phase Synchronous Motor
5. Load test on three-phase squirrel cage induction motor
6. Load test on three-phase slip ring induction motor
7. Predetermination of performance characteristics of three-phase induction motor by circle diagram and equivalent circuit.
8. Separation of No-load losses of three-phase induction motor
9. Load test on single-phase induction motor

10. Equivalent circuit of single-phase induction motor.

d. Activities

Students shall be exposed to the hands on experience on different types of AC machines in the college premises.

e. Learning Resources

Text Books

1. A.E. Fitzgerald, Charles Kingsley, Stephen. D. Umans, *Electric Machinery*, Mc Graw Hill, 2003
2. Stephen J. Chapman, *Electric Machinery Fundamentals*, 4th Edition, McGraw Hill, 2010

Reference Books

1. Gupta, J.B., *Theory & performance of electrical machines,* SK Kataria and Sons, 2014
2. Del Toro, V.,*Basic electric machines*, Pearson India Education. 2016
3. P.S. Bhimbhra., *Electrical Machinery*, Khanna Publishers, 2003
4. D.P. Kothari and I.J. Nagrath., *Electric Machines*, 5th Edition, McGraw Hill, 2018
5. Vedam Subrahmaniam, *Electric Drives (Concepts and Applications)*, Tata McGraw-Hill, 2010

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	Synchronous Induction motor 3HP	1
2.	DC Shunt Motor Coupled With Three phase Alternator	4
3.	DC Shunt Motor Coupled With Three phase Slip ring Induction motor	1
4.	Three Phase Induction Motor with Loading Arrangement	2
5.	Single Phase Induction Motor with Loading Arrangement	2
6.	Tachometer -Digital/Analog	8
7.	Single Phase Auto Transformer	2
8.	Three Phase Auto Transformer	3
9.	Single Phase Resistive Loading Bank	2
10.	Three Phase Resistive Loading Bank	2
11.	Capacitor Bank	1

Course Code	Course Name	L	T	P	C
EE2305	**MICROPROCESSORS AND MICROCONTROLLERS LABORATORY**	**0**	**0**	**4**	**2**

Category: Professional Core

a. Preamble

This course introduces the writing practice of assembly language in microprocessor and microcontrollers. It gives the idea of developing assembly language program from algorithm. The basic concepts of interfacing microprocessor with peripheral devices are also discussed.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Develop assembly language program using 8085 microprocessor	K3
CO2	Develop assembly language program using 8051 microcontroller	K3
CO3	Design and implement interfacing of peripheral devices with microprocessor and microcontroller	K4
CO4	Design and simulate microprocessor based systems used for control and monitoring	K4
CO5	Design and simulate microcontroller based systems used for control and monitoring	K4

c. Course Syllabus **Total : 60 Periods**

PROGRAMMING EXERCISES / EXPERIMENTS WITH µP8085:

1. Simple arithmetic operations: Multi precision addition / subtraction /multiplication / division.
2. Programming with control instructions: Increment / Decrement, Ascending / Descending order, Maximum / Minimum of numbers
3. Interface Experiments: A/D Interfacing. D/A Interfacing
4. Stepper motor controller interface.

PROGRAMMING EXERCISES / EXPERIMENTS WITH µC8051:

5. Simple arithmetic operations with 8051: Multi precision addition / subtraction / multiplication/ division.
6. Programming with control instructions: Increment / Decrement, Maximum / Minimum of numbers

7 Interface Experiments: Stepper motor controller interface.

PROGRAMMING EXERCISES / EXPERIMENTS WITH ARDUINO:

8 Distance Measurement

9 Object Detection

10 Stepper Motor Control/Servo Motor Control

11 Programming PIC architecture with software tools.

d. Activities

Students shall be exposed to the hands on experience on different Microprocessor and microcontroller training kit

e. Learning Resources

Text Books

1. Ramesh S. Gaonkar, *Microprocessor Architecture Programming and Application*, Pen ram International (P) Ltd., Mumbai, 6th Education, 2013.
2. Muhammad Ali Mazidi & Janice Gilli Mazidi, *The 8051 Micro Controller and Embedded Systems,* Pearson Education, Second Edition 2011.
3. Muhammad Ali Mazidi & Janice Gilli Mazidi, *The PIC Micro Controller and Embedded Systems,* Pearson Education, 2010.

Reference Books

1. Douglas V. Hall, *Microprocessors & Interfacing*, Tata McGraw Hill 3rd Edition, 2017.
2. Krishna Kant, *Microprocessors & Microcontrollers*, Prentice Hall of India, 2007.
3 Michael Margolis, *Arduino Cookbook*, O'Reilly, 2011.
4 Kenneth Ayala, *The 8051 Microcontroller*, Thomson, 3rd Edition, 2004.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S. No.	Description of Equipment	Quantity Required
1.	Microprocessor 8085 Trainer Kit	10
2.	Microcontroller Training Kit	10
3.	A/D Converter Module	5
4.	D/A Converter Module	5
5.	Keyboard and Display Interface	5
6.	Traffic Light Module	3
7.	Stepper Motor Module	5
8.	PIC IDE	Open Source
9.	Arduino Uno	10

10.	Ultrasonic Sensor Module	5
11.	IR Module	5
12.	Stepper Motor with driver	5
13.	Servo Motor	5
14.	Arduion IDE	Open Source

Course Code	Course Name	L	T	P	C
EM2351	PROFESSIONAL COMMUNICATION	0	0	2	1

Category: Employability Enhancement Courses

a. Preamble

The course aims to:

• Enhance the Employability and Career Skills of students.

• Orient the students towards grooming as a professional.

• Make them Employable Graduates.

• Develop their confidence and help them attend interviews successfully.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Apply hard and soft skills to enhance their employability	K3
CO2	Utilize adequate presentation skills to present a PPT	K3
CO3	Utilize the proper usage of grammar in GD	K3
CO4	Make use of the acquired skills while attending interviews	K3
CO5	Develop adequate Soft Skills required for the workplace	K3

c. Course Syllabus **Total : 30 Periods**

SOFT SKILLS **6**

Introduction to Soft Skills– Hard skills & soft skills – employability and career Skills—Grooming as a professional with values—Time Management—General awareness of Current Affairs.

EFFECTIVE PRESENTATIONS **6**

Self-Introduction-organizing the material – Introducing oneself to the audience – introducing the topic – answering questions – individual presentation practice— presenting the visuals effectively – 5 minute presentations.

GROUP DISCUSSION **6**

Introduction to Group Discussion— Participating in group discussions – understanding group dynamics – brainstorming the topic -– questioning and clarifying –GD strategies- activities to improve GD skills.

INTERVIEW ETIQUETTE **6**

Interview etiquette – dress code – body language – attending job interviews– telephone/skype interview -one to one interview &panel interview – FAQs related to job interviews.

CAREER PLAN **6**

Recognizing differences between groups and teams- managing time-managing stress- networking professionally- respecting social protocols-understanding career management - developing a long-term career plan-making career changes.

d. Activities

Students shall be trained in Individual Presentation, Group Discussion and Mock Interview.

e. Learning Resources

Reference Books

1. Butterfield, Jeff *Soft Skills for Everyone*. Cengage Learning: New Delhi, 2015.
2. E. Suresh Kumar et al. *Communication for Professional Success*. Orient Blackswan: Hyderabad, 2015.
3. *Interact English Lab Manual for Undergraduate Students*, Orient BlackSwan: Hyderabad, 2016.
4. Raman, Meenakshi and Sangeeta Sharma, *Professional Communication*. Oxford University Press: Oxford, 2014.
5. S. Hariharanet al. *Soft Skills*. MJP Publishers: Chennai, 2010.

Course Code	Course Name	L	T	P	C
EM2301	**INTERNSHIP**	**0**	**0**	**0**	**1**

Category: Employability Enhancement Course

a. Preamble

To enable the students to

- Get connected with industry/ laboratory/research institute.
- Get practical knowledge on production process in the industry and develop skills to solve industry related problems.
- Develop skills to carry out research in the research institutes/laboratories.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Validate system-level processes, techniques, manufacturing and production processes in the industry/research facilities of the laboratory/research institute.	K5
CO2	Analyse the solutions of industry/research problems.	K4
CO3	Document system specifications, design methodologies, process parameters, testing parameters and results.	K2
CO4	Comprehend the process followed in the industry/research institute in the form of presentation .	K2
CO5	Demonstrate the technical knowledge observed in the industry/research institute with the courses studied.	K2

c. Course Instruction

The students individually undergo training in reputed industry/ research institutes/ laboratories for the specified duration. After completion of the training, a detailed report should be submitted within ten days from the commencement of next semester. The evaluation will be done as per the Regulations. Credits shall be awarded to the students who satisfy the clauses for industrial training/ internship of the Regulation concerned.

Course Code	Course Name	L	T	P	C
EE2351	**POWER ELECTRONICS**	**3**	**0**	**0**	**3**

Category: Professional Core

a. Preamble

This course introduces the various power semiconductor devices and different types of converters for electrical system.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Identify and select the switching devices for different power converter applications	K3
CO2	Develop a suitable power converter for given dc load specification from AC input.	K3
CO3	Develop and analyze different DC-DC converter with various loads.	K3
CO4	Develop and analyze the single-phase inverter and three-phase inverters.	K3
CO5	Identify appropriate control strategy for single-phase and three-phase AC to AC converters.	K3

c. Course Syllabus **Total : 45 Periods**

POWER SEMICONDUCTOR DEVICES **9**

Introduction – Power Diode, BJT, MOSFET, IGBT, SCR, TRIAC, GTO - Construction, Principle of operation, Static and Dynamic characteristics, Triggering and Commutation circuit for SCR, Driver and snubber circuit, Gate pulse generation circuit

PHASE CONTROLLED CONVERTERS **9**

2-pulse, 3-pulse and 6-pulse converters– performance parameters –Effect of source inductance–Dual converters, Applications

DC TO DC CONVERTERS **9**

Principle of Step Up and Down Chopper – Chopper Control Strategies – Quadrant of Operation: single quadrant, two quadrant and four quadrant DC Choppers – Introduction to Voltage regulator – Buck, Boost, Buck – Boost Converters

INVERTERS **9**

Single phase and three phase voltage source inverters (both120^0 mode and 180^0 mode)–Voltage & harmonic control--PWM techniques: Multiple PWM, Sinusoidal PWM, modified sinusoidal PWM –Current source inverter, Applications

AC TO AC CONVERTERS **9**

Single phase and Three phase AC voltage controllers–Control strategy- Power Factor Control – Multistage sequence control -single phase and three phase cyclo converters – Introduction to Matrix converters, Applications

d. Activities

Students shall be exposed to different types of AC-DC converters, Inverters, DC-DC Converters and AC-AC Converters.

e. Learning Resources

Text Books

1. Rashid, M.H., *Power electronics: circuits, devices, and applications* Pearson Education India, 2017.
2. Mohan, N., Undeland, T.M. and Robbins, W.P., *Power Electronics converters, applications, and design*, John wiley & son, 2003.

Reference Books

1. P.S. Bimbra, *Power Electronics*, Khanna Publishers, 6th Edition, 2018.
2. Vedam Subrahmanyam, *Power Electronics*, New Age International (P) Limited, New Delhi, 2nd Edition, 2006.

4 Soumitra Kumar Mandal, *Power Electronics*, McGraw Hill publishers Pvt. Ltd, 2014.

5 Umanand, L, *Power Electronics: Essentials and Applications*, Wiley India Pvt. Limited, 2009.

Course Code	Course Name	L	T	P	C
EE2352	**POWER SYSTEM OPERATION AND CONTROL**	**3**	**0**	**0**	**3**

Category: Professional Core

a. Preamble

This course introduces the Indian power scenario and load forecasting, real power frequency control and reactive power voltage control methods. This course also includes the concept of economic dispatch and unit commitment.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Illustrate the load curve, load forecasting techniques and speed governing mechanism.	K2
CO2	Construct the model for real power-frequency dynamics of single area and two area system.	K3
CO3	Apply suitable reactive power compensation technique for effective voltage control.	K3
CO4	Solve the economic dispatch and unit commitment problem using analytical approach.	K3
CO5	Explain the computer control for real time power system monitoring and control.	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **9**

Power scenario in Indian grid – National and Regional load dispatching centers – necessity of voltage and frequency regulation – system load variation, load curves and basic concepts of load dispatching - load forecasting and its model (Similar-day approach and Regression methods) - Basics of speed governing mechanisms and modeling - speed load characteristics - regulation of two generators in parallel.

REAL POWER - FREQUENCY CONTROL **9**

Load Frequency Control (LFC) of single area system-static and dynamic analysis of uncontrolled and controlled cases - LFC of two area system - tie line modeling – block diagram representation of two area system - static and dynamic analysis - tie line with frequency bias control.

REACTIVE POWER – VOLTAGE CONTROL **9**

Generation and absorption of reactive power - Automatic Voltage Regulator (AVR) - block diagram representation of AVR loop - static and dynamic analysis – voltage drop in transmission line - methods of reactive power injection - tap changing transformer, SVC (TCR + TSC) and STATCOM for voltage control.

ECONOMIC OPERATION OF POWER SYSTEM **9**

Statement of economic dispatch problem - Input and output characteristics of thermal plant - incremental cost curve - optimal operation of thermal units without and with transmission losses (no derivation of transmission loss coefficients) - Statement of unit commitment (UC) - constraints on UC problem – UC Solution methods (priority list method).

COMPUTER CONTROL OF POWER SYSTEM **9**

Need of computer control of power systems-concept of energy control centers and functions - system monitoring, data acquisition and controls - System hardware configurations - SCADA and EMS functions - Various operating states - state transition diagram.

d. Activities

Students shall be exposed to the basic power system operation, control and economic impact in the college premises.

e. Learning Resources

Text Books

1. Wood, A.J., Wollenberg, B.F. and Sheblé, G.B., *Power generation, operation, and control*, John Wiley & Sons, 2013.
2. Kundur, P., Balu, N.J. and Lauby, M.G., *Power system stability and control* (Vol. 7), New York: McGraw-hill, 2006.

Reference Books

1. Sivanagaraju, S., *Power system operation and control*, Pearson Education India, 2009.
2. Wadhwa, C.L., *Electrical power systems*, New Age International, 2009.

Course Code	Course Name	L	T	P	C
EE2353	**MINI PROJECT**	**0**	**0**	**3**	**1**

Category: Employability Enhancement Course

a. Preamble

The main objective is to give an opportunity to the student to gain valuable insights, foster creativity, acquire technical skills and share knowledge by effective collaboration. This endeavor serves as a platform for as to explore, create and learn.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Identify a potential problem based on literature survey and real time needs.	K3
CO2	Categorize various solution methodologies to solve problem taken for study.	K3
CO3	Design and develop solution for the proposed problem.	K3
CO4	Infer the experimental results based on hardware & software implementation.	K3
CO5	Analyze the results with the existing solutions.	K3

c. Guideline for Review and Evaluation **Total: 45 Periods**

The students will be working in single or group of 3 to 4 on a scientific problem approved by the Head of the Department under the guidance of the faculty member and prepare a comprehensive report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on project evaluation process as recommended in the respective regulation.

Course Code	Course Name	L	T	P	C
EE2354	**POWER ELECTRONICS LABORATORY**	**0**	**0**	**4**	**2**

Category: Professional Core

a. Preamble

This laboratory course helps the students to study the characteristics of switching devices and its applications in rectifier, inverter, chopper and resonant converter.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Evaluate the static and dynamic characteristics of SCR, TRIAC, MOSFET and IGBT.	K4
CO2	Demonstrate fully controlled and half controlled rectifiers and also its firing circuits.	K3
CO3	Apply various PWM techniques for IGBT based single-phase and three-phase inverters	K3
CO4	Experiment with the various types of AC voltage controller	K3
CO5	Analyze the characteristics of various converter fed drives.	K4

c. Course Syllabus

Total : 60 Periods

1. Gate Pulse Generation using R, RC and UJT triggering circuit
2. Characteristics of SCR
3. Characteristics of MOSFET
4. Performance Analysis of Half and Fully controlled Converter with R and RL load
5. Performance Analysis of Step down and step up MOSFET based choppers
6. Performance Analysis of IGBT based single phase PWM inverter
7. Performance Analysis of IGBT based three phase PWM inverter
8. Performance Analysis of AC Voltage controller
9. Simulation of Power Electronic circuits (1Φ & 3Φ semi converters, 1Φ & 3Φ full converters, DC - DC Converters, AC voltage controllers)
10. Speed control of BLDC motor and Induction motor

d. Activities

Students shall be exposed to the hands on experience with different Converters, Inverters and Voltage controllers through simulation and experimental studies.

e. Learning Resources

Text Books

1. Rashid, M.H., *Power electronics: circuits, devices, and applications*, Pearson Education India, 2009.
2. P.S. Bimbra, *Power Electronics*, Khanna Publishers, 6th Edition, 2008.

Reference Books

1. Mohan, N., Undeland, T.M. and Robbins, W.P., *Power electronics: converters, applications, and design*, John wiley & sons, 2018.
2. Vedam Subrahmanyam., *Power Electronics*, New Age International (P) Limited, New Delhi, 2^{nd} Edition, 2006.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	Device characteristics (for SCR, MOSFET, TRIAC, GTO, IGCT and IGBT kit with built-in /discrete power supply and meters)	2 each
2.	Single phase SCR based half controlled converter and fully controlled converter along with built-in /separate/firing circuit/module and meter	2 each
3.	MOSFET based step up and step down choppers (Built in/ Discrete)	1 each
4.	IGBT based single phase PWM inverter module/Discrete Component	2
5.	IGBT based three phase PWM inverter module/Discrete Componen	2
6.	Switched mode power converter module/Discrete Component	2
7.	SCR &TRIAC based 1 phase AC controller along with lamp or rheostat load	2
8.	Cyclo converter kit with firing module	1
9.	Dual regulated DC power supply with common ground	1
10.	Cathode ray Oscilloscope	10
11.	Isolation Transformer	5
12.	Single phase Auto transformer	3
13.	Components (Inductance, Capacitance)	3 set for each

S.No.	Description of Equipment	Quantity Required
14.	Multi meter	5
15.	LCR meter	3
16.	Rheostats of various ranges	2 sets of 10 Value
17.	Work tables	10
18.	DC and AC meters of required ranges	20
19.	BLDC motor	1
20.	Component data sheets to be provided	-

Course Code	Course Name	L	T	P	C
EE2355	**POWER SYSTEM SIMULATION LABORATORY**	**0**	**0**	**4**	**2**

Category: Professional Core

a. Preamble

This laboratory course introduces modeling of transmission lines and formation of network matrices. It also includes the power flow studies, fault studies and stability studies on power system networks.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Construct a program to compute transmission line parameters (L and C) for given conductor configuration.	K3
CO2	Construct a program to form network matrices (Ybus and Zbus) for various power system studies.	K3
CO3	Simulate the given power system network using available software and obtain its load flow solution.	K3
CO4	Simulate the given power system network for symmetrical and unsymmetrical fault analysis.	K3
CO5	Construct a program to obtain optimal unit allocation for a given system demand.	K3

c. Course Syllabus **Total: 60 Periods**

1. Computation of Transmission Line Parameters (L and C)
2. Formation of Bus Admittance using two rule method
3. Formation of Bus Impedance Matrices using bus building method
4. Power Flow Analysis using Gauss-Seidel Method
5. Power Flow Analysis using Newton Raphson Method
6. Symmetric fault analysis
7. Unsymmetrical fault analysis
8. Transient stability analysis of SMIB System
9. Economic Dispatch in Power Systems
10. Load – Frequency Dynamics of Single- Area and Two-Area Power Systems

d. Activities

Students shall be exposed to the power system under steady state and faulted conditions using suitable software.

e. Learning Resources

Text Books

1. Kothari D.P. and Nagrath I.J.,*Power System Engineering*, Tata McGraw-Hill Education, Second Edition, 2008.
2. Kundur, P.S. and Malik, O.P, *Power system stability and control*, McGraw-Hill Education, 2022.

Reference Books

1. John J. Grainger, William D. Stevenson, Jr, *Power System Analysis*, McGraw Hill Education (India) Private Limited, New Delhi, 2015.
2. Pai, M.A. and Chatterjee, D., *Computer techniques in power system analysis*, New Delhi: Tata McGraw-Hill, 2021.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	Personal computers (Intel i3, 80GB, 2GBRAM)	30 Numbers
2.	Printer laser	1 No.
3.	Server (Intel i5, 80GB, 2GBRAM) (High Speed Processor)	1 No.
4.	Software: any power system simulation software with	5 user license
5.	Compliers: C, C++, VB, VC++	30 users

Course Code	Course Name	L	T	P	C
VEE311	**POWER PLANT ENGINEERING**	**3**	**0**	**0**	**3**

Category: Professional Elective

a. Preamble

This course introduces the basic concepts of various power plants such as Thermal power plant, Diesel power plant, Gas turbine power plant, Nuclear power plant and renewable energy sources. It also deals about the environmental issues of various power plants.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the layout, construction and working of the components in thermal power plants.	K2
CO2	Summarize the layout, construction and working of the components in a Diesel, Gas and Combined cycle power plants.	K2
CO3	Illustrate the layout, construction and working of the components in nuclear power plants.	K2
CO4	Demonstrate the layout, construction and working of the components in Renewable energy power plants.	K2
CO5	Explain the environmental hazards and estimate the costs of electrical energy production.	K2

c. Course Syllabus **Total : 45 Periods**

COAL BASED THERMAL POWER PLANTS 9

Rankine cycle - improvisations, Layout of modern coal power plant, Super Critical Boilers, FBC Boilers, Turbines, Condensers, Steam & Heat rate, Subsystems of thermal power plants – Fuel and ash handling, Draught system, Feed water treatment. Binary Cycles and Cogeneration systems.

DIESEL, GAS TURBINE AND COMBINED CYCLE POWER PLANTS 9

Otto, Diesel, Dual & Brayton Cycle - Analysis & Optimisation. Components of Diesel and Gas Turbine power plants. Combined Cycle Power Plants. Integrated Gasifier based Combined Cycle systems.

NUCLEAR POWER PLANTS **9**

Basics of Nuclear Engineering, Layout and subsystems of Nuclear Power Plants, Working of Nuclear Reactors : Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), CANada Deuterium- Uranium reactor (CANDU), Breeder, Gas Cooled and Liquid Metal Cooled Reactors. Safety measures for Nuclear Power plants.

POWER FROM RENEWABLE ENERGY **9**

Hydro Electric Power Plants – Classification, Typical Layout and associated components including Turbines. Principle, Construction and working of Solar PhotoVoltaic (SPV), Wind, Tidal, Solar Thermal and Geo Thermal.

ENERGY, ECONOMIC AND ENVIRONMENTAL ISSUES OF POWER PLANTS **9**

Demand based tariff- Power tariff types, Load distribution parameters, load curve, Comparison of site selection criteria, relative merits & demerits, Capital & Operating Cost of different power plants. Pollution control technologies including Waste Disposal Options for Coal and Nuclear Power Plants.

d. Activities

Students shall be exposed to the function of different power plants, their merits and demerits available in the college premises and through field visits.

e. Learning Resources

Text Book

1. Nag. P.K., *Power Plant Engineering*, Third Edition, Tata McGraw – Hill Publishing Company Ltd, 2017.

Reference Books

1. El-Wakil. M.M.,*Power Plant Technology*, Tata McGraw – Hill Publishing Company Ltd, 2010.
2. Boyle, G., *Renewable energy*, Open University, 2012.
3. Thomas C. Elliott, Kao Chen and Robert C. Swanekamp, *Power Plant Engineering*, Second Edition, Standard Handbook of McGraw – Hill, 2012.

Course Code	Course Name	L	T	P	C
VEE312	UTILIZATION AND CONSERVATION OF ELECTRICAL ENERGY	3	0	0	3

Category: Professional Elective

a. Preamble

This course introduces the basic concepts of electric drives and traction motors. The course deals with the conservation of electrical power and faults debugging.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the appropriate type of electric supply system and evaluate the performance of a traction unit.	K2
CO2	Apply the various schemes of illumination for energy saving.	K3
CO3	Interpret the appropriate method of heating and welding for a given industrial application.	K2
CO4	Explain the energy conservation schemes and working of energy efficient equipment.	K2
CO5	Make use of a battery charging circuit for a specific household application and acquaint the domestic electric connection.	K3

c. Course Syllabus **Total : 45 Periods**

TRACTION **9**

Merits of electric traction – requirements of electric traction system – supply systems, traction motors, power transformers - characteristic features of traction motor - systems of railway electrification - - train movement and energy consumption - traction motor control - track equipment and collection gear- electric braking- recent trends in electric traction.

ILLUMINATION **9**

Introduction - definition and meaning of terms used in illumination engineering - photometry -classification of light sources - incandescent lamps, sodium vapour lamps, mercury vapour lamps, fluorescent lamps – design of illumination systems - indoor lighting schemes - factory lighting halls - outdoor lighting schemes - flood lighting - street lighting – LED lighting and energy efficient lamps.

HEATING AND WELDING **9**

Introduction - advantages of electric heating – modes of heat transfer - Role of electric heating for industrial applications -methods of electric heating- resistance heating - arcfurnaces - induction heating - dielectric heating - electric welding – resistance welding - arc welding - radiation welding- welding generator, welding transformer.

REFRIGERATION AND AIR CONDITIONING **9**

Refrigeration-Domestic refrigerator and water coolers - Air-Conditioning-Various types of air-conditioning system and their applications, smart air conditioning units - Energy Efficient motors: Standard motor efficiency, need for efficient motors, Motor life cycle, Direct Savings and payback analysis, efficiency evaluation factor.

DOMESTIC UTILIZATION OF ELECTRICAL ENERGY **9**

Domestic utilization of electrical energy – House wiring. Induction based appliances, Online and OFF line UPS, Batteries - Power quality aspects – nonlinear and domestic loads – Earthing – Protection Against Lightning - Domestic, Industrial and Substation.

d. Activities

Students shall be exposed to the different illumination, air conditioning and UPS maintenance in the college premises.

e. Learning Resources

Text Books

1. Suryanarayana, N.V., *Utilisation of electric power: Including electric drives and electric traction*, New Age International, 2017.

Reference Books

1. Wadhwa, C.L., *Generation, distribution and utilization of electrical energy,* New Age International, 2005.
2. Gupta, J.B., *Utilisation Electric power and Electric Traction*, S.K.Kataria and Sons, 2009.
3. Partab.H., *Art and Science of Utilisation of Electrical Energy*, DhanpatRai and Co, New Delhi, 2017.
4. *Energy Efficiency in Electric Utilities*, BEE Guide Book.

Course Code	Course Name	L	T	P	C
VEE313	**SOLAR PHOTOVOLTAIC SYSTEM**	**3**	**0**	**0**	**3**

Category: Professional Elective

a. Preamble

This course deals with the design, types, applications of solar PV system and also includes the various inverter structures used in Solar PV system.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the parameters and ratings of solar cell and modules	K2
CO2	Make use of various components intended for solar PV system design	K3
CO3	Apply the design procedures for solar PV systems towards installation	K3
CO4	Explain the photovoltaic inverter structures and its control.	K2
CO5	Illustrate the real time applications of solar PV system.	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO SOLAR PV **9**

Solar cell – Parameters of solar cell – Solar PV module – Ratings and parameters – Measuring module parameters – Solar PV module arrays – Factor affecting electricity generation by a solar cell and solar PV module

TYPES OF PV SYSTEMS **9**

Stand alone, grid connected and hybrid systems – Battery parameters – Battery selection – Charge controllers – DC-DC converters – Inverters – MPPT – Components of grid connected PV systems.

SOLAR PV SYSTEM DESIGN **9**

Design methodology for solar PV system: Approximate design of solar PV system – Solar PV system design chart – Look up table for solar PV system design – Installation and troubleshooting of solar PV power plants

PHOTOVOLTAIC INVERTER STRUCTURES **9**

Introduction – Inverter Structures Derived from H-Bridge Topology – Inverter Structures Derived from NPC Topology – Typical PV Inverter Structures – Three-Phase PV Inverters – Control Structures.

APPLICATIONS OF PV SYSTEM **9**

Solar lighting, Solar lantern, Solar street light, home lighting system, water pumping system, Roof top solar power plant – Smart grids

d. Activities

Students shall be exposed to different types PV system design and their applications.

e. Learning Resources

Text Books

1. Teodorescu, R., Liserre, M. and Rodriguez, P., *Grid converters for photovoltaic and wind power systems,* John Wiley & Sons, 2011.

Reference Books

1. Solanki, C.S., *Solar photovoltaics: fundamentals, technologies and applications,* PHI learning Pvt. Ltd, 2015.
2. Patel, M.R., *Wind and solar power systems: design, analysis, and operation,* CRC press, 2005.

Course Code	Course Name	L	T	P	C
VEE314	WIND ENERGY CONVERSION SYSTEM	3	0	0	3

Category: Professional Elective

a. Preamble

This course aims in imparting the concepts of wind energy conversion systems (WECS) along with its design, installation and troubleshooting procedures.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the basic concepts of wind energy conversion system	K2
CO2	Outline the mathematical modeling and control of wind turbines.	K2
CO3	Construct the fixed speed system for WECS and determine its performance.	K3
CO4	Develop the variable speed system for WECS and determine its performance.	K3
CO5	Summarize the grid integration issues and current practices of wind interconnections with power system.	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **9**

Basic aerodynamics, air foils, types and characteristics of wind turbine, turbine design, blade element theory, Betz limit, wake analysis, components of WECS-WECS schemes-Powerobtained from wind-simple momentum theory-Power coefficient- Sabinin’s theory.

WIND TURBINES **9**

Wind turbine rotor design considerations, Aerodynamics of Wind turbine , wind turbine loads, aerodynamic loads in steady operation, wind turbulence, and tower shadow, wind turbine components, braking, yaw system, tower, Tip speed ratio- No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control-stall control-Schemes for maximum power extraction

FIXED SPEED SYSTEMS **9**

Generating Systems- Constant speed constant frequency systems -Choice of Generators- Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model- Generator model for Steady state and Transient stability analysis.

VARIABLE SPEED SYSTEMS **9**

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed variable frequency schemes.

GRID CONNECTED SYSTEMS **9**

Wind interconnection requirements, ramp rate limitations and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state conditions

d. Activities

Students shall be exposed to the modern concepts involved in the design stages of wind turbine blades and their governing principles.

e. Learning Resources

Text Books

1. John, W. and Nicholas, J., *Wind energy technology*, New York: John Wiley and Sons Inc, 1997.

Reference Books

1. Heir, S., Grid Integration of WECS, 1998.
2. Freris, L.L. and Freris, L.L. eds., *Wind energy conversion systems,* (Vol. 31).New York: Prentice Hall, 1990.
3. Bhadra, S.N, Kastha,D, Banerjee,S. *Wind Electrical Systems*, Oxford University Press, 2010.
4. Ion Boldea, *Variable speed generators*, Taylor & Francis group, 2006.

Course Code	Course Name	L	T	P	C
VEE315	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS	3	0	0	3

Category: Professional Elective

a. Preamble

This course introduces the basic concepts of power electronic devices and renewable energy systems. It comprehensively details the different renewable energy source, and different types of converters used in renewable energy systems.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the operating principles and characteristics of renewable energy sources for sustainable energy conversion.	K2
CO2	Choose suitable converter used for Wind energy conversion system.	K3
CO3	Choose appropriate converters used for solar PV System.	K3
CO4	Interpret the performance of stand alone and grid connected renewable energy resources for generating quality power.	K3
CO5	Illustrate the process of extracting maximum power from hybrid energy system and solar PV system.	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO RENEWABLE ENERGY SYSTEMS **9**

Environmental aspects of Renewable Energy System- Solar, Wind, Biomass, Ocean Thermal, Hydrogen energy system- National and International Renewable Energy Program-Cost of installation of various Renewable Energy sources- Operating principles and characteristics of: Solar PV, fuel cells, wind energy.

CONVERTERS FOR WIND **9**

Three phase AC voltage controllers in wind energy conversion- AC – DC converters- PWM Inverters-Grid Interactive Inverters-Matrix converters, Converter for PMSG based Wind energy conversion system- Converter for DFIG based wind energy conversion system.

CONVERTERS FOR SOLAR PV **9**

Block diagram of solar photo voltaic system, Line commutated converters (inversion mode), buck,boost and buck-boost converters, selection of inverter, Battery chargers

CONTROL TECHNIQUES FOR WIND AND SOLAR **9**

Stand alone operation of fixed and variable speed wind energy conversion systems and solar PV system, grid connection issues, grid integrated PMSG and SCIG Based WECS - Grid integrated solar PV system.

HYBRID RENEWABLE ENERGY SYSTEMS **9**

Need for Hybrid Systems: Range and type of hybrid systems, case studies of wind - PV, maximum power point tracking (MPPT), biomass-fuel cell hybrid systems, fuel cell - PV hybrid system and wind-fuel cell hybrid system

d. Activities

Students shall be exposed to the different renewable energy systems and their components.

e. Learning Resources

Text Books

1. Patel, M.R. and Beik, O., *Wind and solar power systems: design, analysis, and operation*, CRC press, 2021.
2. Bimbhra, P.S. and Kaur, S., *Power electronics* (Vol. 2), India: Khanna Publishers, 2012.

Reference Books

1. G D Rai, *Non- Conventional Energy Resources*, Khanna Publishers, 1st Edition, 2001&2002.

Course Code	Course Name	L	T	P	C
VEE316	**ENERGY STORAGE TECHNOLOGIES**	**3**	**0**	**0**	**3**

Category: Professional Elective

a. Preamble

This course aims to introduce the fundamental concepts and principles of various energy storage systems that aids in various real time applications.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the basic concepts and need of different energy storage systems.	K2
CO2	Demonstrate the various types of thermal energy storage systems.	K2
CO3	Summarize the different types related to electric and magnetic energy storage systems.	K2
CO4	Explain the principle of operation and types of various electrochemical storage systems such as fuel cells and battery.	K2
CO5	Apply the real time applications of various energy storage technologies.	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO ENERGY STORAGE SYSTEMS **9**

Necessity of energy storage, different types of energy storage, mechanical, chemical, electrical, electrochemical, magnetic, electromagnetic, thermal and Compressed air storage technology, comparison of energy storage technologies.

THERMAL ENERGY STORAGE SYSTEMS **9**

Thermal Energy storage, sensible and latent heat, phase change materials, Energy and exergy analysis of thermal energy storage, Mechanical-Pumped hydro, flywheels and pressurized air energy storage.

ELECTRIC AND MAGNETIC ENERGY STORAGE SYSTEMS **9**

Electrical Energy storage-Capacitors, Super-capacitors, Hybrid capacitor and Pseudo capacitor-

Magnetic Energy Storage-Working principle of Superconducting Magnetic Energy Storage systems (SMES), applications.

ELECTROCHEMICAL ENERGY STORAGE SYSTEMS 9

Principle of direct energy conversion using fuel cells, thermodynamics of fuel cells, Types of fuel cells-AFC, PEMFC, MCFC, SOFC, Fuel cell performance, Electrochemical Energy Storage- Battery, primary, secondary and flow batteries.

DESIGN AND APPLICATIONS OF ENERGY STORAGE SYSTEMS 9

Renewable energy storage-Battery sizing and stand-alone applications, stationary (Power Grid application), Small scale application-Portable storage systems and medical devices, Mobilestorage Applications- Electric vehicles (EVs), types of EVs, batteries and fuel cells, future technologies, hybrid systems for energy storage.

d. Activities

Students shall be exposed to various energy storage systems and advanced batteries for emerging applications.

e. Learning Resources

Text Books

1. Ahmed Faheem Zobaa, M, Energy *Storage - Technologies and Applications*, InTech, 2013.

Reference Books

1. J. Jensen and B. Sorenson, *Fundamentals of Energy Storage, Wiley-Interscience*, New York, 1984.
2. C. Daniel, J. O. Besenhard, *Handbook of battery materials*, Wiley VCH Verlag GmbH & Co., 2012.
3. Dincer I. and Rosen M. A, *Thermal energy storage: Systems and Applications*, Wiley publication, 2002.

Course Code	Course Name	L	T	P	C
VEE317	**DESIGN, INSTALLATION AND COMMISSIONING OF RENEWABLE ENERGY SYSTEMS**	**3**	**0**	**0**	**3**

Category: Professional Elective

a. Preamble

Design, installation, and commissioning of renewable energy systems involve the process of planning, setting up, and installation of clean energy solutions such as solar, wind, and hydro power systems.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Interpret the components of solar PV systems and the performance of charge controllers and inverters.	K2
CO2	Illustrate design methodology for standalone and grid connected solar PV systems.	K2
CO3	Choose safety requirements and procedures, and diagnose and troubleshoot issues in standalone and grid connected solar PV power plants.	K3
CO4	Compare different methods of generatingsynchronous power using AC and DC generators in wind energy conversion systems.	K2
CO5	Interpret site preparation, electrical network, and equipment selection requirements to develop cost-effective and efficient wind farms.	K2

c. Course Syllabus **Total : 45 Periods**

COMPONENTS OF SOLAR PV SYSTEMS **9**

Stand alone, grid connected and hybrid systems – Battery parameters – Battery selection – Charge controllers – DC-DC converters – Inverters – MPPT – Components of grid connected PV systems.

DESIGN OF SOLAR PV SYSTEM **9**

Design methodology for solar PV system: Approximate design of solar PV system – Configuration of grid connected solar PV systems – Grid connected PV system design for power plants.

SOLAR PV SYSTEM INSTALLATION AND TROUBLESHOOTING **9**

Installation and troubleshooting of standalone solar PV power plants – Safety in installation of PV systems – Installation and troubleshooting of solar PV power plants – Solar PV installation check list.

COMPONENTS FOR WECS **9**

Power output from an ideal turbine – Aerodynamics – Power output from practical turbines – Energy production and capacity factor – Methods of generating synchronous power – DC shunt generator with battery load – AC generators.

DESIGN AND INSTALLATION OF WECS **9**

Site preparation – Electrical network – Selection of low voltage and distribution voltage equipments – Losses – Wind farm costs.

d. Activities

Students shall be exposed to Design projects, equipment selection, site surveying, system installation, testing and commissioning, maintenance planning, and safety regulations training in the college premises.

e. Learning Resources

Text Books

1. Solanki, C.S., *Solar photovoltaic technology and systems: a manual for technicians, trainers and engineers*, PHI Learning Pvt. Ltd., 2013.
2. Johnson, G.L., *Wind energy systems: Electronic Edition*, KS, Manhattan, 2006.

Reference Books

1. Solanki, C.S., *Solar photovoltaics: fundamentals, technologies and applications*, PHI learning pvt. Ltd., 2015.
2. Spera David, A., *Wind Turbine Technology, Fundamental Concepts of Wind Turbine Engineering*, Department of Energy USA, NASA, 2009.

Course Code	Course Name	L	T	P	C
VEE321	**SPECIAL ELECTRICAL MACHINES**	**3**	**0**	**0**	**3**

Category: Professional Elective

a. Preamble

This course aims to introduce the construction, working principle and applications of various special electrical machines such as stepper motor, switched reluctance motor, BLDC motor, PMSM, etc.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Interpret the various modes of excitations, drive circuits and control techniques of stepper motor	K2
CO2	Illustrate the Construction, working and Performance of Switched Reluctance Motor	K2
CO3	Outline the principle of operation and applications of PMBLDC Motor.	K2
CO4	Demonstrate the construction, working principle, performance characteristics and applications of Permanent Magnet Synchronous Motors	K3
CO5	Explain the Construction, working and Performance of Hysteresis Motor, Synchronous Reluctance motor, Linear Induction Motor, AC series motor & Repulsion motor	K2

c. Course Syllabus **Total : 45 Periods**

STEPPER MOTORS **9**

Constructional features –Principle of operation –Types – Torque predictions – Linear Analysis – Characteristics – Drive circuits and current suppression schemes for stepper motor – Closed loop control – Concept of lead angle – Applications of stepper motors in computer peripherals, robotics and 3D printers.

SWITCHED RELUCTANCE MOTORS (SRM) **9**

Constructional features –Principle of operation- Torque prediction–Characteristics - Steady state performance prediction – Analytical Method – Current control schemes- Hysteresis and

PWM- Power controllers – Control of SRM drive- Sensor less operation of SRM – Applications.

PERMANENT MAGNET BRUSHLESS D.C. MOTORS 9

Disadvantages of BLDC motor-Fundamentals of Permanent Magnets- Types- Principle of operation- Magnetic circuit analysis- EMF and Torque equations- Power Converter Circuits and their controllers - Characteristics and control- Applications.

PERMANENT MAGNET SYNCHRONOUS MOTORS (PMSM) 9

Constructional features -Principle of operation – EMF and Torque equations - Sine wave motor with practical windings - Phasor diagram - Power controllers – performance characteristics -Digital controllers – Comparison of PMSM and PMBLDC -Applications.

OTHER SPECIAL MACHINES 9

Constructional features – Principle of operation and Characteristics of Hysteresis motor- Synchronous Reluctance Motor–Linear Induction motor-Repulsion motor- AC series motor- Applications.

d. Activities

Students shall be exposed to the different tupes of special machine construction, working, application, and driving circuits on the college premises.

e. Learning Resources

Text Books

1. K.Venkataratnam, *Special Electrical Machines*, Universities Press (India) Private Limited, 2008.
2. T. Kenjo, *Stepping Motors and Their Microprocessor Controls*, Clarendon Press London, 1984.

Reference Books

1. E.G. Janardanan, *Special electrical machines*, PHI learning Private Limited, Delhi, 2014.
2. R.Krishnan, *Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application*, CRC Press, New York, 2001.

Course Code	Course Name	L	T	P	C
VEE322	**SOLID STATE DRIVES**	**3**	**0**	**0**	**3**

Category: Professional Elective

a. Preamble

Solid state drives deals with the steady state operation and transient dynamics of a motor load system. It helps to understand the operation and performance of AC motor drives, DC motor drives and synchronous motor drives.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Interpret the importance of Electrical drives and their characteristics.	K2
CO2	Explain the operation of the various controlled rectifier and chopper fed DC drives	K2
CO3	Demonstrate the various speed control methods of induction motor drives.	K3
CO4	Experiment with the various speed control methods of synchronous motor drives and the selection of drives for industrial applications	K3
CO5	Illustrate the current and speed controllers for solid state DC motor drives.	K2

c. Course Syllabus **Total : 45 Periods**

DRIVE CHARACTERISTICS 9

Electric drive – Equations governing motor load dynamics – steady state stability – multi quadrant Dynamics: acceleration, deceleration, starting & stopping – typical load torque characteristics –Selection of motor

CONVERTER / CHOPPER FED DC MOTOR DRIVE 9

Steady state analysis of the single and three phase converter fed separately excited DC motor drive– continuous conduction – Time ratio and current limit control – 4 quadrantoperation of converter / chopper fed drive-Applications.

INDUCTION MOTOR DRIVES **9**

Stator voltage control–V/f control– Rotor Resistance control-slip power recovery drives-closed loop control–– vector control- Applications in Textile industries.

SYNCHRONOUS MOTOR DRIVES **9**

V/f control and self-control of synchronous motor: Margin angle control and power factor control-Three phase voltage/current source fed synchronous motor- Applications in Paper mills.

DESIGN OF CONTROLLERS FOR DRIVES **9**

Transfer function for DC motor / load and converter – closed loop control with Current and speed feedback–armature voltage control and field weakening mode – Design of controllers; current controller and speed controller- converter selection and characteristics.

d. Activities

Students shall be exposed to the operation of controlled rectifier, chopper fed DC Drives. Speed control of Induction motor and synchronous motor drives.

e. Learning Resources

Text Books

1. Dubey, G.K., *Fundamentals of electrical drives,* CRC press, 2002.
2. Bose, B.K., *Modern power electronics and AC drives* (Vol. 123), Upper Saddle River, NJ: Prentice hall, 2002.
3 Krishnan, R., *Electric motor drives: modeling, analysis, and control*, Pearson, 2001.

Reference Books

1. Vedam Subramanyam, *Electric Drives Concepts and Applications 2e,* McGraw Hill, 2016.
2. Shaahin Felizadeh, *Electric Machines and Drives*, CRC Press (Taylor and Francis Group), 2013.
3 Hindmarsh, J. and Renfrew, A., *Electrical machines and drives*, Elsevier, 1996.
4 Wildi, T., *Electrical machines, drives, and power systems,* Pearson Education, 2006.
5 Sen, P.K., *Electric drives,* PHI Learning Pvt. Ltd, 1999.

Course Code	Course Name	L	T	P	C
VEE323	**MODERN POWER CONVERTERS**	**3**	**0**	**0**	**3**

Category: Professional Elective

a. Preamble

This course is designed to impart knowledge about the configuration, control strategies and back to back converter for power electronics circuits.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Outline different configurations of power electronics circuit	K2
CO2	Explain the various PWM topologies for power converters	K2
CO3	Illustrate the various control strategies used in power converters	K2
CO4	Interpret the performance of single phase to singlephase back to back converter	K2
CO5	Identify the performance of switched mode DC-DC converters	K3

c. Course Syllabus **Total : 45 Periods**

CONFIGURATION OF POWER ELECTRONICS CIRCUIT **9**

Neutral point clamped configuration: Three level and Five level configurations – cascade configuration: single and two H bridge converter – PWM Implementation of single and two H bridge converter – Flying Capacitor (FC) configuration: three phase FC converter

OPTIMIZED PWM APPROACH **9**

Introduction – two leg and three leg converter: Model, PWM implementation, Analog and digital implementation – space vector modulation – other configuration with CPWM: three leg and four converter – Non-conventional topologies with CPWM: Z-Source converter.

CONTROL STRATEGIES FOR POWER CONVERTERS **9**

Introduction – basic control principles – hysteresis control – linear control with DC variable: P, PI and PID controller for RL load – linear control with ac variable – cascade control strategies: rectifier circuit for voltage and current control.

SINGLE PHASE TO SINGLE PHASE BACK TO BACK CONVERTERS 9

Introduction – Full Bridge converter: Model, PWM strategy, control approach – topology with component count reduction: Model – PWM strategies – Topologies with increased number of switches: converter in series and parallel

DESIGN OF CONVERTER 9

Introduction – Switched Mode DC-to-DC Converter – Design constraints of reactive elements: Design of inductor, transformer and capacitors, Input filter requirement – boundary between continuous and discontinuous conduction – critical values of inductance/load resistance.

d. Activities

Students shall be exposed to the configuration and control strategies of converters used in power electronic circuits.

e. Learning Resources

Text Books

1. Erickson, R.W. and Maksimovic, D., *Fundamentals of power electronics,* Springer Science & Business Media, 2007.
2 Dos Santos, E. and Da Silva, E.R., *Advanced power electronics converters: PWM converters processing AC voltages,* John Wiley & Sons, 2014.

Reference Books

1. William Shepherd and Li zhang., *Power Converters Circuits*, Routledge and CRC Press, 2005.
2. Ang, S., Oliva, A., Griffiths, G. and Harrison, R., *Power-switching converters,* CRC press, 2010.
3 Trzynadlowski, A.M., *Introduction to modern power electronics,* John Wiley & Sons, 2005.

Course Code	Course Name	L	T	P	C
VEE324	DESIGN OF ELECTRICAL MACHINES	3	0	0	3

Category: Professional Elective

a. Preamble

This course aims in imparting knowledge to the students about fundamental aspects and consideration of different parameters for proper design of static and rotating dc and ac electrical rotating machines.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Classify the various fundamental aspects and materials used for electrical machines.	K2
CO2	Identify the various components of dc motor by considering load requirement	K3
CO3	Make use of the various components of transformer by considering load requirement	K3
CO4	Model the various components of induction motor by considering load requirement	K3
CO5	Select the various components of synchronous machine by considering load requirement	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **9**

Major considerations in Electrical Machine Design – Electrical Engineering Materials – Space factor – Choice of Specific Electrical and Magnetic loadings – Thermal considerations – Heat flow – Temperature rise and Insulating Materials – Rating of machines – Standard specifications.

DC MACHINES **9**

Output Equation – Main Dimensions – Choice of Specific Electric and Magnetic Loading – Magnetic Circuits Calculations – Carter's Coefficient – Net length of Iron – Real & Apparent flux densities –Selection of number of poles – Design of Armature – Design of commutator and brushes – performance prediction using design values.

TRANSFORMERS **9**

Output Equation – Main Dimensions – kVA output for single and three phase transformers – Window space factor – Design of core and winding – Overall dimensions – Operating characteristics – No load current – Temperature rise in Transformers – Design of Tank – Methods of cooling of Transformers.

INDUCTION MOTORS **9**

Output equation of Induction motor – Main dimensions – Choice of Average flux density – Length of air gap- Rules for selecting rotor slots of squirrel cage machines – Design of rotor bars & slots – Design of end rings – Design of wound rotor – Magnetic leakage calculations – Leakage reactance of polyphase machines- Magnetizing current – Short circuit current – Operating characteristics- Losses and Efficiency.

SYNCHRONOUS MACHINES **9**

Output equation – choice of Electrical and Magnetic Loading – Design of salient pole machines – Short circuit ratio – shape of pole face – Armature design – Armature parameters – Estimation of air gap length – Design of rotor –Design of damper winding – Determination of full load field mmf – Design of field winding – Design of turbo alternators – Rotor design.

d. Activities

Students shall be exposed to the design of static and rotating DC and AC electrical machines

e. Learning Resources

Text Books

1. Sawhney, A.K. and Chakrabarti, A., Electrical machine design, D*hanpat Rai and Co.,* 2017.

Reference Books

1. Mittle, V.N. and Mittal, A., *Design of electrical machines,* NC Jain, 2009.
2. Agarwal, R.K., *Principles of electrical machine design*, SK Kataria and Sons, 2013.

Course Code	Course Name	L	T	P	C
VEE325	HYBRID ELECTRIC VEHICLE	3	0	0	3

Category: Professional Elective

a. Preamble

This course introduces the basic concepts of electric vehicle architecture, different types of electric vehicles and their performance. It comprehensively details the different Energy storage devices and Energy management concepts used in hybrid electric vehicles.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the concepts of Electric and Hybrid Electric Vehicles	K2
CO2	Demonstrate the architecture and sizing of Electric and Hybrid Electric Vehicles.	K2
CO3	Experiment with the concept of Plug-in Hybrid Electric Vehicles	K3
CO4	Explain the concepts of different Drive train system used in Hybrid electric vehicles.	K2
CO5	Summarize the various Energy storage devices and Energy Management strategies used in Hybrid Electric vehicles.	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO ELECTRIC AND HYBRID VEHICLES **9**

History of Electric Vehicles, Development towards 21st Century, Types of Electric Vehicles in use today – Battery Electric Vehicle, Hybrid (ICE & others), Fuel Cell EV, Solar Powered Vehicles, Motion and Dynamic Equations of the Electric Vehicles: various forces acting on the Vehicle in static and dynamic conditions, Social and environmental importance of hybrid and electric vehicles.

VEHICLE ARCHITECTURE AND SIZING **9**

Series, Parallel and Series parallel Architecture, Micro and Mild architectures. Mountain Bike - Motorcycle- Electric Cars and Heavy Duty EVs. -Details and Specifications

PLUG-IN HYBRID ELECTRIC VEHICLE **9**

Introduction-History-Comparison with electrical and hybrid electrical vehicle-Construction and working of PHEV-Block diagram and components-Charging mechanisms-Advantages of PHEVs.

ELECTRIC DRIVE TRAIN SYSTEM **9**

Basic concept of electric traction, introduction to various electric drive- train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis, Electric Propulsion unit: Introduction to electric components used in hybrid electric vehicles, drive system efficiency.

ENERGY STORAGE AND ENERGY MANAGEMENT STRATEGIES **9**

Introduction to energy storage requirement in hybrid electric vehicles, Battery, Fuel cell, Super capacitor and flywheel based energy storage and its analysis, Energy Management Strategies: Introduction to energy management strategies used in hybrid electric vehicles, classification of different energy management strategies,comparison of different energy management strategies, implementation issues of energy management strategies. Case Studies: Design of a Hybrid Electric Vehicle (HEV).

d. Activities

Students shall be exposed to the plug-in hybrid electric vehicles and their components through field visit.

e. Learning Resources

Text Books

1. Larminie, J. and Lowry, J., *Electric vehicle technology explained*. JohnWiley & Sons, 2012.
2. Husain, I., *Electric and hybrid vehicles: design fundamentals.* CRC press, 2010.

Reference Books

1. Ehsani, M., Gao, Y., Longo, S. and Ebrahimi, K.M., *Modern electric, hybrid electric, and fuel cell vehicles*. CRC press, 2018.
2. Onori, S., Serrao, L. and Rizzoni, G., *Hybrid electric vehicles: Energy management strategies,* 2016.

Course Code	Course Name	L	T	P	C
VEE326	**ELECTRIC VEHICLES AND ENERGY MANAGEMENT**	**3**	**0**	**0**	**3**

Category: Professional Elective

a. Preamble

This course introduces the basic concepts of different types of electric vehicles, propulsion unit and drive trains. It comprehensively details the different energy storage devices and energy management strategies used in electric vehicles.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the concepts of Electric Vehicles and its topologies.	K2
CO2	Develop an Electric propulsion unit and its control for applications of Electric Vehicles.	K3
CO3	Demonstrate Electric drive train and power converter topologies used for Electric Vehicle applications.	K2
CO4	Apply the concepts of different energy storage devices used in Electric Vehicles.	K3
CO5	Illustrate the various Energy Management strategies and its implementation in Electric vehicles.	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO ELECTRIC VEHICLES 9

Components of Electric Vehicle, Comparison with Internal combustion Engine: Technology, Benefits and Challenges, EV classification and their electrification levels, Configurations of Electric Vehicles (EV), Performance of EV, and Architectures of EV.

ELECTRIC PROPULSION UNIT AND DRIVE DRAINS 9

Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

DRIVE TRAINS AND DRIVE SYSTEM **9**

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Sizing the propulsion motor, Sizing the Power Electronics, Selecting the energy storage technology, communications, and supporting sub systems.

ENERGY STORAGE SYSTEMS **9**

Batteries - Advanced Lithium Batteries and Beyond lithium batteries, Lead-acid battery, High temperature batteries for back-up applications, Double layer and Super capacitors for e-mobility application, Fuel Cells and Hydrogen Storage

ENERGY MANAGEMENT STRATEGIES **9**

Handling Analysis of Electric and Hybrid Electric Vehicles - Simplified Handling Models Energy/Power Allocation and Management - Power/Energy Management Controllers – Rule Based Control Strategies - Optimization-Based Control Strategies

d. Activities

Students shall be exposed to the different types of electric vehicles and their internal parts through field visit.

e. Learning Resources

Text Books

1. Larminie, J. and Lowry, J., *Electric vehicle technology explained*, John Wiley & Sons, 2012.
2. Husain, I., *Electric and hybrid vehicles: design fundamentals*, CRC press, 2010.

Reference Books

1. Ehsani, M., Gao, Y., Longo, S. and Ebrahimi, K.M., *Modern electric, hybrid electric, and fuel cell vehicles*, CRC press, 2018.

Course Code	Course Name	L	T	P	C
VEE327	DESIGN OF ELECTRIC VEHICLE CHARGING SYSTEM	3	0	0	3

Category: Professional Elective

a. Preamble

Design of Electric Vehicle Charging system deals with the standards used in charging system, concepts of power converters in charging and also the charging schemes used in renewable based EV charging system.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the various charging techniques and charging standards to be followed.	K2
CO2	Explain the working of DC-DC converters used for charging systems and principles.	K2
CO3	Demonstrate the concept of EV charging with renewable energy system and battery system.	K2
CO4	Summarize the principles of operation, types and parameter estimation in battery system.	K2
CO5	Outline the principles of wireless power transfer used in electric vehicles.	K2

c. Course Syllabus **Total : 45 Periods**

CHARGING STATIONS AND STANDARDS **9**

Introduction-Charging technologies- Conductive charging, EV charging infrastructure, International standards and regulations - Inductive charging, need for inductive charging of EV, Modes and operating principle, Static and dynamic charging, Bidirectional power flow, International standards and Regulations

POWER ELECTRONICS FOR EV CHARGING **9**

Layouts of EV Battery Charging Systems-AC charging-DC charging systems- Power Electronic Converters for EV Battery Charging- AC–DC converter with boost PFC circuit, with bridge and without bridge circuit - Bidirectional DC–DC Converters- Non-isolated DC–DC bidirectional converter topologies- Half-bridge bidirectional converter

EV CHARGING USING RENEWABLE AND STORAGE SYSTEMS **9**

Introduction- - EV charger topologies , EV charging/discharging strategies - Integration of EV charging-home solar PV system , Operation modes of EVC-HSP system , Control strategy of EVCHSP system - fast-charging infrastructure with solar PV and energy storage.

ENERGY STORAGE SYSTEMS **9**

Battery: Principle of operation, types, models, estimation of parameters, battery modeling, SOC of battery, Traction Batteries and their capacity for standard drive cycles, Vehicle to Grid operation of EV's

WIRELESS POWER TRANSFER **9**

Introduction - Inductive, Magnetic Resonance, Capacitive types. Wireless Chargers for Electric Vehicles - Types of Electric Vehicles - Battery Technology in EVs -Charging Modes in EVs – Benefits of WPT. - WPT Operation Modes - Standards for EV Wireless Chargers, SAE J2954, IEC 61980. ISO 19363

d. Activities

Students shall be exposed to the design concepts of charging system used in Electric vehicles.

e. Learning Resources

Text Books

1. Patel, N., Bhoi, A.K., Padmanaban, S. and Holm-Nielsen, J.B. eds., *Electric vehicles: modern technologies and trends* (pp. 107-117). Singapore: Springer, 2021.

Reference Books

1. Wang, M., Shen, X.S. and Zhang, R., *Mobile electric vehicles*. Berlin: Springer, 2016.
2. Triviño-Cabrera, A., González-González, J.M. and Aguado, J.A., Wireless power transfer for electric vehicles: foundations and design approach, 2020.
3 Singh, R., Sanjeevikumar, P., Kumar, D.S., Molinas, M. and Blaabjerg, F., *Cable Based and Wireless Charging Systems for Electric Vehicles: Technology and control, management and grid integration*. Institution of Engineering and Technology, 2021.

4 Halderman, J.D., *Electric and Hybrid Electric Vehicles*. Pearson Education, Incorporated, 2023.

5 Emadi, A. ed., *Handbook of automotive power electronics and motor drives*. CRC press, 2017.

Course Code	Course Name	L	T	P	C
VEE331	DISTRIBUTED GENERATION AND MICROGRID	3	0	0	3

Category: Professional Elective

a. Preamble

This course introduces the basic concepts of Distributed generation (DG) of electricity based on renewable energy sources such as wind and solar. It also introduces the concept of DC and AC microgrid and its control aspects.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the impact of Distributed Generation and construction /working principle of various DG plants.	K2
CO2	Demonstrate the various distributed generators and their system Studies.	K2
CO3	Illustrate the planning and protection schemes of Distributed Generation.	K2
CO4	Interpret the concept of Microgrid and its mode of operation.	K2
CO5	Develop the modelling and control of Microgrid and its SoS operation.	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO DISTRIBUTED GENERATION 9

Need for distributed generation – Technical and Economic impacts of generation on the distribution system - Impact of distributed generation on the distribution system, transmission system, and the central generation - Distributed generation plant: Combined heat and power plants-Small-scale hydro generation-Wind power plant-Offshore wind energy-Solar photovoltaic generation.

DISTRIBUTED GENERATORS AND SYSTEM STUDIES 9

Distributed generators: Synchronous generators, Induction generators, Doubly fed induction generator, Full power converter (FPC) connected generators - System studies: Load flow studies in a simple radial system, Load flow studies in meshed systems, Symmetrical fault studies, Unbalanced (asymmetrical) fault studies.

DG PROTECTION AND PLANNING **9**

Fault current from distributed generators- Fault current limiters - Protection of distributed generation - Impact of distributed generation on existing distribution system protection - Distributed generation and adequacy of supply - Impact of distributed generation on network design.

CONCEPT OF MICROGRID **9**

Introduction to Microgrids (AC and DC Microgrid) - Control Approaches – System of Systems - Modeling and Analysis of Inverter Based Microgrids.

FRAMEWORK FOR MICROGRID **9**

Microgrid Subsystems - The Concept of SoS - Modeling of Microgrid - Microgrid Control Architecture - Application to Islanded Microgrid.

d. Activities

Students shall be exposed to the DG and microgrid operation, control and different types available in the college premises.

e. Learning Resources

Text Books

1. Jenkins, N., Ekanayake, J.B. and Strbac, G., *Distributed Generation*, London, UK: Inst. Eng. Technol, 2010.
2. Mahmoud, M.S. and Fouad, M., *Control and optimization of distributed generation systems* (p. 368). Cham, Switzerland: Springer International Publishing, 2015.

Reference Books

1. S. Chowdhury, S.P. Chowdhury and P. Crossley, *Microgrids and Active Distribution Networks*, London, UK, Inst. Eng. Technology, 2009.
2. Bollen, M.H. and Hassan, F., *Integration of distributed generation in the power system*. John wiley & sons, 2011.

Course Code	Course Name	L	T	P	C
VEE332	**SMART GRID TECHNOLOGIES**	**3**	**0**	**0**	**3**

Category: Professional Elective

a. Preamble

This course introduces the basic concepts of Smart Grid over conventional grid and various national and international policy frame work. The concept of Smart Grid technologies involves in transmission, distribution system, different smart meters and advanced metering infrastructure.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Interpret the concepts of smart grid and its present developments in national and international scenario.	K2
CO2	Explain the different transmission technologies such as smart energy resources, smart substations and phasor measurement units in smart grid.	K2
CO3	Illustrate different distribution technologies such as volt /VAR control, Demand response management and Plug in hybrid Electric Vehicles (PHEV) in smart grid.	K2
CO4	Apply the concept of smart meters and advanced metering infrastructure devices.	K3
CO5	Make use of LAN, WAN, cloud computing and cyber security in smart grid environment.	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO SMART GRID **9**

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid, Diverse perspectives from experts and global Smart Grid initiatives.

SMART GRID TECHNOLOGIES- TRANSMISSION SYSTEMS **9**

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: phasor measurement units, Wide area monitoring, Protection and control.

SMART GRID TECHNOLOGIES- DISTRIBUTION SYSTEMS **9**

DMS, Volt/VAR control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Demand Response Management, Plug in Hybrid Electric Vehicles (PHEV).

SMART METERS AND ADVANCED METERING INFRASTRUCTURE **9**

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Intelligent Electronic Devices (IED) & their application for monitoring & protection.

HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS **9**

Local Area Network(LAN),House Area Network(HAN), Wide Area Network(WAN), Broad band over Power line(BPL),IP based Protocols, Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.

d. Activities

Students shall be exposed to the smart grid technologies and advanced metering systems through simulation studies.

e. Learning Resources

Text Books

1. Keyhani, A. and Albaijat, M. eds., *Smart power grids,* Springer Science & Business Media, 2012.
2. Momoh, J.A., *Smart grid: fundamentals of design and analysis* (Vol. 63, John Wiley & Sons, 2012.

Reference Books

1. Borlase, S. ed., *Smart grids: infrastructure, technology, and solutions*. CRC Press, 2017.
2. Ekanayake, J.B., Jenkins, N., Liyanage, K.M., Wu, J. and Yokoyama, A., *Smart grid: technology and applications*, John Wiley & Sons, 2012.
3. Berger, L.T. and Iniewski, K. *Smart grid applications, communications, and security*. John Wiley & Sons, 2012.

Course Code	Course Name	L	T	P	C
VEE333	SOFT COMPUTING TECHNIQUES	3	0	0	3

Category: Professional Elective

a. Preamble

This course provides knowledge on ANN, Fuzzy logic and ANFIS systems for modeling & control of various applications. Further, a flavour of evolutionary optimization techniques with simple case study is also touched upon.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the fundamentals of ANN and various types of networks and their algorithms.	K2
CO2	Demonstrate ANN controller for the given non-linear system.	K2
CO3	Interpret the basic concepts involved in fuzzy logic and various terminologies.	K2
CO4	Construct a fuzzy logic controller for a given application.	K3
CO5	Develop hybrid control system for simple applications.	K3

c. Course Syllabus **Total : 45 Periods**

ARTIFICIAL NEURAL NETWORK **9**

Review of fundamentals – Biological neuron, artificial neuron, activation function, single layer perceptron – Limitation – Multi layer perceptron – Back Propagation Algorithm (BPA) – Recurrent Neural Network (RNN) – Adaptive Resonance Theory (ART) based network – Radial basis function network – online learning algorithms, BP through time – RTRL algorithms – Reinforcement learning

NEURAL NETWORKS FOR MODELING AND CONTROL **9**

Modelling of non-linear systems using ANN – Generation of training data – Optimal architecture– Model validation – Control of non-linear systems using ANN – Direct and indirect neuro control schemes – Adaptive neuro controller – Familiarization with neural network toolbox- Neural Network based controller.

FUZZY SET THEORY **9**

Fuzzy set theory – Fuzzy sets – Operation on fuzzy sets – Scalar cardinality, fuzzy cardinality, union and intersection, complement (Yager and Sugeno), equilibrium points, aggregation, projection, composition, cylindrical extension, fuzzy relation – Fuzzy membership functions.

FUZZY LOGIC FOR MODELING AND CONTROL **9**

Modelling of non-linear systems using fuzzy models – TSK model – Fuzzy logic controller – Fuzzification – Knowledge base – Decision making logic – Defuzzification – Adaptive fuzzy systems – Familiarization with fuzzy logic toolbox – Fuzzy logic applications.

HYBRID CONTROL SCHEMES **9**

Fuzzification and rule base using ANN – Neuro fuzzy systems – ANFIS – Fuzzy neuron– GA – Optimization of membership function and rule base using Genetic Algorithm – Introduction to other evolutionary optimization techniques, support vector machine– Case study – Familiarization with ANFIS toolbox – Applications of hybrid systems to engineering problems.

d. Activities

Students shall be exposed to the different neuro,fuzzy, hybrid systems and its applications in simulation packages such as MATLAB.

e. Learning Resources

Text Books

1. Deepa, S.N. and Sivanandam, S.N., *Principles of Soft Computing*, 2011.

2. Jang, J.S.R., Sun, C.T. and Mizutani, E., *Neuro-Fuzzy and Soft Computing* by PHI, Eastern economy edition, 2004.

Reference Books

1. Rajasekaran, S. and Pai, G.V., *Neural networks, fuzzy logic and genetic algorithm: synthesis and applications*, PHI Learning Pvt. Ltd, 2003.
2. Klir, G.J., St. Clair, U. and Yuan, B., *Fuzzy set theory: foundationsapplications.* Prentice-Hall, Inc., 1997.

Course Code	Course Name	L	T	P	C
VEE334	POWER QUALITY	3	0	0	3

Category: Professional Elective

a. Preamble

This course is intended to provide tools to classify, quantify, and analyze the power quality problems and to provide practical engineering solutions to mitigate these problems. The objectives of this course is to make the students understand the various power quality issues and mitigation methods.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the various sources, effects and types of power quality issues in electrical systems.	K2
CO2	Relate the causes & mitigation techniques of PQ events namely voltage sag and swell	K2
CO3	Outline the concept of causes, effects, indices and standards of harmonics.	K2
CO4	Illustrate the construction, working & limitation of custom power devices.	K2
CO5	Interpret various methods used for power quality monitoring & their standards.	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO POWER QUALITY **9**

Terms and Definitions of Power Quality- Need for a quality power - General Classes of Power Quality Problems- Transients - Long-Duration Voltage Variations - Short-Duration Voltage Variations - Voltage Imbalance - Waveform Distortion - Voltage Fluctuation- Power Frequency Variations- Power Quality Terms- CBEMA Curves

VOLTAGE SAG AND SWELL **9**

Estimating voltage sag performance - Analysis and calculation of various fault conditions - Estimation of the sag severity - Mitigation of voltage sag, Static transfer switches and fast transfer switches - Capacitor switching - Lightning - Ferro resonance - Mitigation of voltage swell.

HARMONICS **9**

Harmonic sources from commercial and industrial loads - Locating harmonic sources – Power system response characteristics - Harmonics Vs transients. Effect of harmonics – Harmonic distortion - Voltage and current distortions - Harmonic indices - Inter harmonics – Resonance Harmonic distortion evaluation, IEEE and IEC standards.

CUSTOM POWER DEVICES **9**

Construction, Working and limitation: Distribution STATCOM (D- STATCOM), Dynamic Voltage Restorer (DVR), Unified Power Quality Conditioner (UPQC).

POWER QUALITY MONITORING **9**

Monitoring considerations – Power Quality measurement equipment: Multimeters, Oscilloscopes, Harmonic / spectrum analyzer , Flicker meters, Disturbance analyzer, Combination disturbance and harmonic analyzers - Applications of expert systems - Power Quality Monitoring Standards: IEEE 1159 and IEC (61000-4-30).

d. Activities

Students shall be exposed to laboratory setup & simulation tools to monitor and solve various power quality issues.

e. Learning Resources

Text Books

1. Dugan, R.C., McGranaghan, M.F. and Beaty, H.W., *Electrical power systems quality*. New York, 1996.
2. Singh, B., Chandra, A. and Al-Haddad, K., *Power quality: problems and mitigation techniques*. John Wiley & Sons, 2014.

Reference Books

1. Heydt, G.T., *Electric power quality* (pp. 1985-1993). West Lafayette, IN: Stars in a circle publications, 1991.
2. Ghosh, A. and Ledwich, G., *Power quality enhancement using custom power devices*. Springer science & business media, 2012.

Course Code	Course Name	L	T	P	C
VEE335	**HIGH VOLTAGE ENGINEERING**	**3**	**0**	**0**	**3**

Category: Professional Elective

a. Preamble

This course introduces the basic concepts of over voltage phenomenon and insulation coordination in electrical power systems. It comprehensively details the breakdown mechanisms and the dielectric tests on various electrical equipment and safety precautions.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Relate the causes and effects of over voltages in power system and devise appropriate protection scheme.	K2
CO2	Summarize the different breakdown mechanisms in solid, liquid and gaseous dielectrics.	K2
CO3	Apply the appropriate generation methods of high voltages and currents.	K3
CO4	Demonstrate the various measurement techniques of high voltages and high currents.	K2
CO5	Interpret the high voltage testing procedures of electrical power apparatus and insulation coordination.	K2

c. Course Syllabus **Total : 45 Periods**

OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS **9**

Introduction to High voltage AC / DC system – Causes of over voltages and its effects on power system – Lightning, switching surges and temporary over voltages – Estimation of over voltages- Reflection and Refraction of Travelling waves- Bewley lattice diagram - Protection against over voltages. Insulation Coordination.

DIELECTRIC BREAKDOWN **9**

Properties of Dielectric materials - Gaseous breakdown in uniform and non-uniform fields – Corona discharges – Vacuum breakdown – Conduction and breakdown in pure and commercial liquids, Maintenance of oil Quality – Breakdown mechanisms in solid and composite dielectrics- Applications of insulating materials in electrical equipments.

GENERATION OF HIGH VOLTAGES AND HIGH CURRENTS **9**

Generation of High DC voltage: Rectifiers, voltage multipliers, vandigraff generator- generation of high AC voltages: cascaded transformers, resonant transformer and tesla coil - generation of high impulse voltage: single and multistage Marx circuits – generation of switching surges – generation of impulse currents - Triggering and control of impulse generators.

MEASUREMENT OF HIGH VOLTAGES AND HIGH CURRENTS **9**

High Resistance with series ammeter – Dividers, Resistance, Capacitance and Mixed dividers - Peak Voltmeter, Generating Voltmeters - Capacitance Voltage Transformers, Electrostatic Voltmeters – Sphere Gaps - High current shunts- Digital techniques in high voltage measurement.

HIGH VOLTAGE TESTING OF EQUIPMENT AND HIGH VOLTAGE LABORATORY PRACTICES **9**

High voltage testing of electrical power apparatus as per International and Indian standards – Power frequency, impulse voltage and DC testing of Insulators, bushing, isolators, circuit breakers and transformers, high voltage laboratory layout, indoor and outdoor laboratories, testing facility requirements, safety precautions in H.V. Labs.

d. Activities

Students shall be exposed to the different HV connections, Generation and measurement techniques available in the college premises.

e. Learning Resources

Text Books

1. Naidu, M.S., and Naidu, M.K., *High voltage engineering*, Tata McGraw-Hill Education. 2013.

Reference Books

1. Hugh M. Ryan, *High Voltage Engineering and Testing*, 2nd edition, The Institution of Electrical Engineers, London, United Kingdom, 2001.
2. Rakosh Das Begamudre, *High Voltage Engineering, Problems and Solutions*, New Age International Publishers, New Delhi. 2010.
3. Kuffel, J. and Kuffel, E, *High voltage engineering fundamentals*, Elsevier, 2000.
4. Wadhwa C.L., *High voltage Engineering*, New Age International Publishers, 2010.

Course Code	Course Name	L	T	P	C
VEE336	**PLC AND SCADA**	**3**	**0**	**0**	**3**

Category: Professional Elective

a. Preamble

This course introduces the assembly language programming in basic microprocessors and microcontrollers. It describes the architecture and applications of 8085, 8051, Arduino and PIC microcontroller.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the basic concept and different programming languages of PLC	K2
CO2	Summarize the different Ladder logic instructions in PLC	K2
CO3	Compare the concepts of different PLC Programming languages	K2
CO4	Demonstrate the applications of PLC with Ladder diagram	K2
CO5	Explain the basics in SCADA unit and its operation	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO PLC **9**

PLC-Basic Concepts- Evolution-Building blocks of PLC-Types of PLC -Advantage of PLC over relay- Different programming languages of PLC

LADDER LOGIC DIAGRAM **9**

Basics of PLC Programming-Data manipulation and math instructions-Program Control instructions- Timer/ Counter instructions

PLC PROGRAMMING LANGUAGES **9**

Functional Block Diagram-Sequential Functional Chart- Instruction list- Structured Tect Programming

APPLICATIONS OF PLC **9**

On-Off Control – Object Counter- Traffic Light Controller- Bottle Filling System

INTRODUCTION TO SCADA **9**

Hardware and Software -Remote Terminal Units- Master station and communication architecture- Case study of SCADA

d. Activities

Students shall be exposed to Siemens software to perform PLC Ladder logic diagram

e. Learning Resources

Text Books

1. F.D.Petruzella, *Programmable Logic Controller,* Tata Mc Graw Hill, 2022.
2. James A.Rehg & Glen J.Sartori, *Programmable Logic Controller,* Pearson Education, Second Edition, 2009.

Reference Books

1. T.A.. Huges, *Programmable Controllers,* ISA Press, Fourth edition, 2021.
2. E.A, Parr, *Programmable Controller,* An Engineer's Guide, Elseivier, 2013.
3 G.Clarke, D.Reynders, and E.Wright , *Practical Modern SCADA Protocols DNP3,4 60870 and related systems,* Newnes, 2004.

Course Code	Course Name	L	T	P	C
VEE337	**DIGITAL SIGNAL PROCESSING**	**3**	**0**	**0**	**3**

Category: Professional Elective

a. Preamble

This course introduces the basic concepts of analyzing discrete time signals & systems in time and frequency domain through z-transform. It also describes the design of digital filters and architecture of programmable digital signal processor.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Classify the given signal or system based on its mathematical representation and explain the various sampling and quantization techniques in digital signal representation.	K2
CO2	Solve the given discrete time system using Z-transform and analyze its stability using frequency response and determine the DTFT of a given discrete sequence.	K3
CO3	Solve DFT and Inverse DFT using Radix-2 DIT and DIF FFT algorithms.	K3
CO4	Develop FIR filter using Windowing Technique and IIR filter using Bilinear Transformation and Impulse Invariant Techniques and also to design Analog filters for Butterworth and Chebyshev approximations.	K3
CO5	Illustrate the architecture and functional modes of commercial digital signal processors	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **9**

Classification of systems: Continuous, discrete, linear, causal, stable, dynamic, recursive, time variance- classification of signals: continuous and discrete, energy and power; mathematical representation of signals- spectral density- sampling techniques, quantization, quantization error, Nyquist rate, aliasing effect and digital signal representation.

DISCRETE TIME SYSTEM ANALYSIS **9**

Z-transform and its properties, inverse Z-transforms; difference equation – Solution by Z-transform, application to discrete systems - Stability analysis, frequency response – Convolution – Introduction to Fourier Transform– Discrete time Fourier transform.

DISCRETE FOURIER TRANSFORM & COMPUTATION **9**

DFT properties, magnitude and phase representation - Computation of DFT using FFT algorithm – DIT & DIF - FFT using radix 2 – Butterfly structure.

DESIGN OF DIGITAL FILTERS **9**

FIR & IIR filter realization – Parallel & cascade forms. FIR design: Windowing Techniques – Need and choice of windows – Linear phase characteristics. IIR design: Analog filter design - Butterworth and Chebyshev approximations; digital design using impulse invariant and bilinear transformation - Warping, prewarping -Frequency transformation.

DIGITAL SIGNAL PROCESSORS **9**

Introduction – Architecture of DSP processor TMS320c6713 – Features – Addressing Formats– Functional modes - Introduction to Commercial Processors

d. Activities

Students shall be exposed to the concepts of basic signals, Z-transform, DFT, filters and DSP processors.

e. Learning Resources

Text Books

1. Proakis, J.G., *Digital signal processing: principles, algorithms, and applications, 4/E*. Pearson Education India, 2007.

Reference Books

1. Schilling, R.J. and Harris, S.L., *Digital signal processing using MATLAB*, Cengage Learning, 2016.
2. Mitra, S.K., *Digital signal processing: a computer-based approach* (Vol. 1221). New York, NY, USA:: McGraw-Hill. 2011.
3. A.NagoorKani, *Digital Signal Processing*, Second Edition, McGraw Hill Education Pvt. Ltd, 2018.
4. Poorna Chandra S, Sasikala. B, *Digital Signal Processing* , Vijay Nicole / TMH, 2013.

Course Code	Course Name	L	T	P	C
MEE101	**BATTERY MANAGEMENT SYSTEM**	**3**	**0**	**0**	**3**

Category: Open Elective (Minor Degree)

a. Preamble

This course introduces the basic concepts of batteries, its parameters, modelling and charging requirements. It also demonstrates the battery management strategies for different types of batteries.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Interpret the role of battery management system	K2
CO2	Illustrate the requirements of battery management system	K2
CO3	Build the concept associated with battery charging / discharging process	K3
CO4	Solve the various parameters of battery and battery pack units.	K3
CO5	Develop a model for battery pack through proper design and analyze its performance	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION 9

Introduction to Battery Management System, Cells & Batteries, Nominal voltage and capacity, C rate, Energy and power, Cells connected in series, Cells connected in parallel, Electrochemical and lithium-ion cells, Rechargeable cell, Charging and Discharging Process, Overcharge and Undercharge, Modes of Charging

BATTERY MANAGEMENT SYSTEM REQUIREMENT 9

Introduction and BMS functionality, Battery pack topology, BMS Functionality, Voltage Sensing, Temperature Sensing, Current Sensing, BMS Functionality, High-voltage contactor control, Isolation sensing, Thermal control, Protection, Communication Interface, Range estimation, State-of-charge estimation, Cell total energy and cell total power.

BATTERY STATE OF CHARGE AND STATE OF HEALTH ESTIMATION 9

Battery state of charge estimation (SOC), voltage-based methods to estimate SOC, Model-based state estimation, Battery Health Estimation, Lithium-ion aging: Negative electrode, Lithium ion aging: Positive electrode, Cell Balancing, Causes of imbalance, Circuits for balancing

MODELLING AND SIMULATION **9**

Equivalent-circuit models (ECMs), Physics-based models (PBMs), Empirical modelling approach, Physics-based modelling approach, Simulating an electric vehicle, Vehicle range calculations, Simulating constant power and voltage, Simulating battery packs.

DESIGN OF BATTERY **9**

Design principles of battery BMS, Effect of distance, load, and force on battery life and BMS, energy balancing with multi-battery system

d. Activities

Students shall be exposed to the different HV connections, Generation and measurement techniques available in the college premises.

e. Learning Resources

Text Books

1. Plett, Gregory L. *Battery management systems, Volume I: Battery modeling*. Artech House, 2015.
2. Plett, Gregory L. *Battery management systems, Volume II: Equivalent- circuit methods*. Artech House, 2015.

Reference Books

1. Bergveld, H.J., Kruijt, W.S., Notten, P.H.L, *Battery Management Systems - Design by Modelling*, Philips Research Book Series, 2002.
2. Davide Andrea, ,*Battery Management Systems for Large Lithium-ion Battery Packs*, Artech House, 2010.

Course Code	Course Name	L	T	P	C
MEE102	**ELECTRIC VEHICLE TECHNOLOGIES**	**3**	**0**	**0**	**3**

Category: Open Elective (Minor Degree)

a. Preamble

This course introduces the basic concepts of different types of electric vehicles and their performance. It comprehensively details the different Energy storage devices and Energy management concepts used in electric vehicles.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the concepts of Electric traction and electric drive topologies.	K2
CO2	Develop an Electric propulsion unit and its control for applications of Electric Vehicles.	K3
CO3	Summarize the different Energy storage devices suitable for electric vehicles.	K2
CO4	Apply the propulsion and power converter topologies used for Electric Vehicle applications.	K3
CO5	Relate the Energy Management strategies in the context of Electric vehicles.	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO ELECTRIC VEHICLES 9

Introduction to conventional vehicles, electric drive – trains: Basic concepts of Electrictraction, Introduction to various electric drive – train topologies, Power flow control in electric drive – train topologies, efficiency analysis.

ELECTRIC PROPULSION UNIT AND DRIVE DRAINS 9

Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configurationand control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

ENERGY STORAGE **9**

Introduction to energy storage requirement in electric vehicles, Battery, Fuel cell, Super capacitor and flywheel based energy storage and its analysis. Battery Basics, Different types, Battery Parameters, Battery modeling, Traction Batteries, Battery Management system for Lithium ion Batteries.

DRIVE SYSTEM **9**

Sizing the propulsion motor, Sizing the Power Electronics, Selecting the energy storage technology, communications, and supporting sub systems.

ENERGY MANAGEMENT STRATEGIES **9**

Introduction to Energy Management Strategies used in electric vehicles, Classification of different Energy Management Strategies, comparison of different Energy Management Strategies, Implementation issues of Energy Management Strategies. Case study : Battery Electric Vehicle (BEV)

d. Activities

Students shall be exposed to the different electric vehicles and their internal parts.

e. Learning Resources

Text Books

1. James Larminie, John Lowry, *Electric Vehicle Technology Explained*, Wiley, 2003.
2. Iqbal Hussein, *Electric and Hybrid Vehicles: Design Fundamentals,* CRC Press, 2011.

Reference Books

1. Ehsani, M., Gao, Y., Longo, S. and Ebrahimi, K., *Modern electric, hybrid electric,* and fuel cell vehicles, CRC press, 2018.

Course Code	Course Name	L	T	P	C
MEE103	**GREEN ENERGY TECHNOLOGIES**	**3**	**0**	**0**	**3**

Category: Open Elective (Minor Degree)

a. Preamble

This course introduces the energy scenario and energy economics and need for non-conventional energy sources such as solar, wind, hydro, biomass, etc.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the significance of various renewable energy resources and energy storage technology.	K2
CO2	Summarize materials, types and applications of solar PV and Thermal energy storage system.	K2
CO3	Explain the principle of working & types of hydro power plant and Ocean energy.	K2
CO4	Illustrate the utilization of other energy sources such as wind, geothermal & bio-mass energy.	K2
CO5	Interpret the emerging energy technologies and its applications.	K2

c. Course Syllabus **Total : 45 Periods**

ENERGY SCIENCE AND TECHNOLOGY **9**

Energy, Economy and Social Development - Classification of Energy Sources - Importance of Non-Conventional Energy Sources- Energy Chain- Common Forms of Energy - Advantages and Disadvantages of Conventional Energy Sources - Salient Features of Non- Conventional Energy Sources - Environmental Aspects of Energy – Introduction to Energy Conservation - important aspects of energy conservation - Necessity of Energy Storage,
Energy Storage Devices and Energy Storage Methods.

SOLAR ENERGY **9**

Sun as Source of Energy - Depletion of Solar Radiation - Measurement of Solar Radiation - Solar Radiation on Inclined Plane Surface - Solar Collectors - Solar Water Heater - Solar Thermo-Mechanical System - Solar Cell: Fundamentals, Characteristics, Classification, Technologies, Module, and Array Construction - Maximum Power Point Tracker- Solar PV Systems - Solar PV Applications

HYDRO ENERGY **9**

Essential components of Hydroelectric Systems - Classification of Hydro power schemes Ocean Thermal Energy Conversion (OTEC): Availability, theory and working principle, performance and limitations - Wave and Tidal Energy: Principle of working, performance and limitations - Advantages and Disadvantages of Small Hydro Schemes - Layout of a Micro-Hydro scheme

WIND, GEOTHERMAL & BIO-MASS ENERGY **9**

Wind Energy: Wind power and its sources, site selection, Types of WECS, Performance and limitations of energy conversion systems - Geothermal Energy: Sources of geothermal energy, geothermal Power plant, and environmental considerations - Bio-mass: Availability of bio-mass and its conversion theory.

EMERGING ENERGY TECHNOLOGIES **9**

Fuel Cell - Hydrogen as Energy Carrier - Magneto Hydrodynamic Power Conversion - Thermoelectric Power Conversion - Thermionic Power Conversion.

d. Activities

Students will be involved in solar and wind power generation, monitoring and analysis training on the college campus itself.

e. Learning Resources

TEXT BOOKS

1. Khan, B.H., *Non-conventional energy resources*. Tata McGraw-Hill Education, 2006.
2. Twidell, J. and Weir, T., *Renewable energy resources*. Routledge, 2015.

REFERENCE BOOKS

1. Maczulak, A., *Renewable Energy Sources and Methods: Green Technology*, 2017
2. Hossain, J. and Mahmud, A. eds., *Renewable energy integration: challenges and solutions*. Springer Science & Business Media, 2014.

Course Code	Course Name	L	T	P	C
MEE104	**DC AND AC MICROGRID**	**3**	**0**	**0**	**3**

Category: Open Elective (Minor Degree)

a. Preamble

The objective of this course is to illustrate the concept of micro sources and storage. It deals with the concept of DC, AC and Hybrid microgrid and its controllers.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the basic concept and types of microgrid	K2
CO2	Explain the basic configurations and control aspects of AC microgrid.	K2
CO3	Illustrate the configurations and control aspects of DC microgrid	K2
CO4	Demonstrate the structure and control aspects of Hybrid microgrid	K2
CO5	Construct a suitable model for control and operation of Microgrid system for various applications	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO MICROGRID **9**

Introduction – The Microgrid Concept – Classification of the Microgrid Concept – Operation and Control of Microgrids – Market Models for Microgrids – Status Quo and Outlook of Microgrid Applications-Overview of microgrid sources.

AC MICROGRID **9**

Opeartion of AC microgrid-Hierarchical Control: Primary, Secondary and Tertiary Control– Primary Control: Droop Control, Virtual Synchronous Generator Control for VSC – Secondary Control – Simulation Studies

DC MICROGRID **9**

Opeartion of DC microgrid- Hierarchical Control: Primary, Secondary and Tertiary Control – Primary Control: Droop Control, Virtual Inertia Control – Secondary Control: Centralized and Decentralized Control – Simulation Studies

HYBRID MICROGRID **9**

Hybrid AC/DC Microgrid Structure: AC Coupled, DC Coupled, AC-DC Coupled –Control Strategies: different modes of operation, during transition – Simulation Studies

CONTROL AND OPERATION OF MICROGRID **9**

Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics, Introduction to smart microgrids.

d. Activities

Students shall be exposed to the operation and control of AC and DC microgrid and their applications.

e. Learning Resources

Text Books

1. Hatziargyriou, N. ed., *Microgrids: architectures and control*. John Wiley & Sons, 2014.

Reference Books

1. Bevrani, H., François, B. and Ise, T., *Microgrid dynamics and control*. John Wiley & Sons, 2017.
2. Fusheng, L., Ruisheng, L. and Fengquan, Z., Microgrid technology and engineering application. *China Electric Power Press*, 2016.
3. Mahmoud, M.S. ed., *Microgrid: advanced control methods and renewable energy system integration*. Elsevier, 2016.
4. Nejabatkhah, F. and Li, Y.W., Overview of power management strategies of hybrid AC / DC microgrid. IEEE Transactions on power electronics, 30(12), pp.7072-7089, 2014.
5. Chauhan, R.K. and Chauhan, K. eds., *Distributed energy resources in microgrids: integration, challenges and optimization*. Academic Press, 2019.

Course Code	Course Name	L	T	P	C
MEE105	**ENERGY MANAGEMENT AND AUDITING**	**3**	**0**	**0**	**3**

Category: Open Elective (Minor Degree)

a. Preamble

The fundamental goal of energy management is to produce goods and provide services with the least cost and least environmental effect. The primary objective of energy audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the impact of energy conservation on current energy scenario.	K2
CO2	Explain the effects of energy management in electric motors	K2
CO3	Demonstrate the effects of energy management in lighting	K2
CO4	Illustrate the various Energy Efficient Technologies in Electrical Systems.	K2
CO5	Interpret the process involved in energy auditing to maximize system efficiency.	K2

c. Course Syllabus **Total : 45 Periods**

ENERGY SCENARIO **9**

Introduction – Primary and Secondary Energy – Commercial and Non Commercial Energy – Renewable and Non Renewable Energy – Energy needs of Growing Economy – Energy and Environment – Energy Security – Energy Conservation and its Importance - BEE Star ratings.

ENERGY MANAGEMENT IN ELECTRIC MOTORS **9**

Losses in electric motors, Motor efficiency, Factors affecting motor performance, Rewinding and motor replacement issues, Energy saving opportunities with energy efficient motors - Motor Efficiency Management.

ENERGY MANAGEMENT IN LIGHTING **9**

Light source, Choice of lighting, Luminance requirements, Energy conservation methods – Lighting Energy Management Steps – Day lighting - Maintenance - Energy Efficiency in Lighting – Case studies.

ENERGY EFFICIENT TECHNOLOGIES IN ELECTRICAL SYSTEMS **9**

Maximum demand controllers, Automatic power factor controllers, Energy efficient motors, Soft starters with energy saver, Variable speed drives, Energy efficient transformers, Electronicballast, Occupancy sensors, Energy efficient lighting controls, Energy saving potential of each technology.

ENERGY AUDIT **9**

Definition, Energy audit - need, Types of energy audit, Methodology of Energy Audit - Energy costs, Benchmarking and Energy performance, Maximizing system efficiencies, Energy Audit Instruments – Energy Monitoring and Targeting.

d. Activities

Students shall be exposed to understand the concepts of Energy Management and Auditing in any organizations.

e. Learning Resources

Text Books

1. Capehart, B.L., Turner, W.C. and Kennedy, W.J., *Guide to energy management*, CRC Press, 2006.

Reference Books

1. Tyagi, A.K. ed., *Handbook on energy audits and management*, Teri, 2003.
2. Desai, S., *Hand book of Energy Audit*. McGraw-Hill Education, 2017.
3. Turner, W.C. and Doty, S., *Energy management handbook* (Vol. 6). Lilburn, GA, USA: Fairmont press, 2007.

Course Code	Course Name	L	T	P	C
MEE106	SENSORS AND INSTRUMENTATION	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course will include a comprehensive description of the fundamental principles of operation of sensors, highlight how these principles impact the use of sensors for applications and different electrical and electronics instruments used for measurement.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the different methods of measurement, standards, Errors and Statistical analysis of sensors data	K2
CO2	Illustrate the working principle and applications of different level and pressure sensors	K2
CO3	Summarize the operation of different types of advanced sensors	K2
CO4	Explain the construction and working principle of different measuring instruments	K2
CO5	Apply the basic concepts of CRO and its usage for the measurement of various parameters and the construction of digital voltmeter and multimeter.	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **9**

Basic Methods of Measurement- Units and Standards-Classification of Errors in Measurement and its elimination- Statistical Methods- Means, Median, Standard Deviations-odds and uncertainity-Definitions and differences between Sensors and Transducers.

LEVEL AND PRESSURE SENSOR **9**

Level Sensors- Capacitance type, Ulltrasonic type, optical type, microwave optical level sensor- simple applications-Pressure Sensors- Manometer, Barometer, Piezoelectric, Strain Gauge- Gauge factor-applications

ADVANCED SENSORS **9**

Fibre optic Sensors-Smart Sensors-MEMS- Thick and Thin Film Sensors- Nano Sensors-SQUID Sensor

ELECTRICAL INSTRUMENTATION **9**

Basics of D'Arsonal Galvanometer- PMMC Instrument-MI Instrument- Electrodynamometer Instrument (Voltmeter and Ammeter)- Rectifier type Instrument

ELECTRONIC INSTRUMENTATION **9**

Introduction and Basic Principles of Oscilloscope- Block diagram and Workingprinciple- CRT Features- Dual Beam and Dual Trace CROs- Measurement of Frequency using Lissajous pattern-Digital Voltmeter- Digital Multimeter.

d. Activities

Students shall be exposed to the demonstration of different sensors and instruments

e. Learning Resources

Text Books

1. Sawhney A.K., *A Course in Electrical and Electronic Measurements and Instrumentations,* Dhanpat Rai, 19th Education, 2011.
2. H.S.Halsi, *Electronic Instrumentation*, Tata McGraw-Hill, 2010.

Reference Books

1. M.M.S.Anand, *Electronic Instruments and Instrumentation Technology,* PHI, 2009.
2. R.P.Northrop, *Introduction to Instruments and Measurements,* Taylor & Francis, 2005.

Course Code	Course Name	L	T	P	C
OEE781	**RENEWABLE ENERGY SOURCES**	**3**	**0**	**0**	**3**

Category: Open Elective

a. Preamble

This course will include a comprehensive descriptions on various Renewable energy sources like solar, wind and biomass energy, geothermal energy, ocean energy & fuel cell.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the significance of various renewable energy resources and Energy storage technology	K2
CO2	Summarize the materials, types and applications of solar PV and Thermal energy storage system	K2
CO3	Explain the principle of working & types of fuel cells & WECS	K2
CO4	Illustrate the concept of geothermal energy and hydro power plant	K2
CO5	Interpret the utilization of other energy sources such as biogas and Ocean energy	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO RENEWABLE ENERGY SOURCES 9

Classification of Energy Sources- Importance of Non-Conventional Energy Sources- Energy Chain- Common Forms of Energy – Advantages and Disadvantages of Conventional Energy Sources – Salient Features of Non-Conventional Energy Sources – Environmental Aspects of Energy – Introduction to Energy Conservation – important aspects of energy conservation – Energy Storage: Necessity of Energy Storage, Energy Storage Devices and Energy Storage Methods.

SOLAR PV AND THERMAL ENERGY 9

Solar Thermal Energy: Solar radiation, flat plate collectors and their materials, applications and performance - solar thermal power plants - Thermal energy storage for solar heating and cooling - limitations. Solar PV Cells: Theory of solar PV cells. Solar PV cell materials, solar

PV array, solar PV power plant, limitations of solar PV. Types of PV power plants (Stand alone & Grid connected)

FUEL CELLS AND WIND ENERGY **9**

Fuel Cells: Principle of working of various types of fuel cells, performance and limitations. Wind power and its sources, site selection, Types of WECS, Based on turbine VAT Turbine, HAT Turbine, Based on Power Delivery: Stand alone & Grid connected. Performance and limitations of energy conversion systems.

GEOTHERMAL ENERGY & HYDRO POWER PLANT **9**

Geothermal Energy: Sources of geothermal energy, geothermal Power plant, environmental considerations. Essential components of Hydroelectric Systems, Classification of Hydro power schemes, Turbine theory, classification of water turbine.

BIO-MASS AND OCEAN ENERGY **9**

Bio-mass: Availability of bio-mass and its conversion theory. Ocean Thermal Energy Conversion (OTEC): Availability, theory and working principle, performance and limitations. Wave and Tidal Energy: Principle of working, performance and limitations.

d. Activities

Students shall be exposed to the Renewable Energy sources available in the college premises.

e. Learning Resources

Text Book

1. Khan, B.H., *Non-conventional Energy Resources,* Tata McGraw-Hill Education, 2006.

Reference Book

1. Twidell, J. and Weir, T., *Renewable Energy Resources,* Routledge, 2015.