Draft Structure and Curriculum for T.Y. B.Tech. in Electrical Engineering

Teaching and Evaluation Scheme

YEAR/SEMESTER-T.Y. B.Tech, Sem-V

Course Code	Course	Curriculum Component	Teaching Scheme				Evaluation Scheme			
			L	T	P	Credits	Component	Max Marks	Min Marks	
UELC0501	Power System Protection	PC	04	--	--	04	ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
UELC0502	Electric Vehicles Technologies	PC	04	--	--	04	ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
UELC0503	Microcontrollers	PC	04	--	--	04	ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
UELE054X	Program Elective-I	PE-I	03	--	--	03	ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
UELO058*	Open Elective-I	OE-I	03	--	--	03	ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
UELA0561	Audit Course-III	HS	02	--	--	--	ESE		100	40
UELC0531	Power System Protection Lab	PC	--	--	02	01	ISE	25	10	
							ESE (POE)	50	20	
UELC0532	Electric Vehicle Lab	PC	--	--	02	01	ISE	25	10	
							ESE (OE)	25	10	
UELC0533	Microcontroller Lab	PC	--	--	02	01	ISE	25	10	
							ESE (POE)	50	20	
UELC0534	Mini Project-II	PRJ	-	-	02	01	ISE	50	20	
Total			**20**	**--**	**08**	**22**	-	**750**	**300**	
TOTAL CONTACT HOURS = 28 , TOTAL CREDITS = 22										

Mrs. S. A. Sarkar
BoS-Member Secretary

Mr. Ajit S.Patil
Dean Academics

Dr. V. S. Bugade
BoS - Chairman

Draft Structure and Curriculum for T.Y. B. Tech. in Electrical Engineering

Teaching and Evaluation Scheme YEAR / SEMESTER-

T.Y. B.Tech, Sem. - VI

Course Code	Course	Curriculum Component	Teaching Scheme				Evaluation Scheme			
			L	T	P	Credits	Component	Max Marks	Min Marks	
UELC0601	Industrial Drives and Control	PC	04	--	--	04	ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
UELC0602	Power System Analysis	PC	04	--	--	04	ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
UELC0603	IOT Electrical Engineering	PC	04	--	--	04	ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
UELE064X	Program Elective-II	PE-II	03	--	--	03	ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
UELO068*	Open Elective-II	OE-II	03	--	--	03	ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
UELA0661	Audit Course-IV	ES	02	--	--	--	ESE	100	40	
UELC0631	Industrial Drives and Control Lab	PC	--	--	02	01	ISE	25	10	
							ESE (POE)	50	20	
UELC0632	Power System Analysis Lab	PC	--	--	02	01	ISE	25	10	
							ESE (POE)	50	20	
UELC0633	IOT Electrical Engineering Lab	PC	--	--	02	01	ISE	25	10	
							ESE (OE)	25	10	
UELC0634	Power Quality and Harmonics Lab	PC	--	--	02	01	ISE	50	20	
Total			**20**	**--**	**08**	**22**	**--**	**750**	**300**	
TOTAL CONTACT HOURS = 28, TOTAL CREDITS = 22										

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BoS-Member Secretary

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Note:-

- **HS:** Humanities, Social Science and Management,
- **BS:** Basic Sciences including Mathematics
- **ES:** Engineering Science,
- **PC:** Program Core,
- **PE:** Program Elective
- **OE:** Open elective, **PRJ**: Project work, Seminar, Internship in industry etc.
- ***:** Course code for Open Elective
- **X** :Course code for Program Elective

List of Program Electives–Semester V and VI

Year	Program Elective	Course Code	Course Name
Third Year B.Tech -Sem-V	Program Elective-I	UELE0541	Utilization of Electrical Energy
		UELE0542	Electrical Auditing and Management.
Third Year B.Tech -Sem-VI	Program Elective-II	UELE0641	Power Quality and Harmonics (PQH)
		UELE0642	Flexible AC transmission systems(FACTS)

List of Open Electives offered to other programs- Semester VI

Year	Open Elective	Course Code	Course Name
Third Year B.Tech-Sem-V	Open Elective-I	UELO0581	Solar Photovoltaic System Design
		UELO0582	Renewable Energy Sources
Third Year B.Tech-Sem-VI	Open Elective-II	UELO0681	Electric Vehicles Technologies
		UELO0682	Electric Motors & its Control

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List of Audit Courses - Semester V and VI

Year	Audit Course	Course Code	Course Name
Third Year B.Tech-Sem-V	Audit Course-III	UELA0561	NPTEL / Course Era /MOOCS
Third Year B.Tech-Sem-VI	Audit Course-IV	UELA0661	NPTEL / Course Era /MOOCS

Note: BoS Chairman has to decide the Audit Course -III in accordance with Curriculum Component Humanities Science(as mentioned in structure)& Audit Course-IV in accordance with Curriculum Component Engineering Science (as mentioned in structure)before the commencement of Semester over NPTEL / Course Era /MOOCS platform, examination of Audit Course will be conducted at Institute level.

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Title of the Course: Power System Protection	L	T	P	Credit
Course Code: UELC0501	04	-	-	04

Course Pre-Requisite: Basic Knowledge Electric Power System, Electrical Power Generation, Transmission and Distribution. Working of Electric Machine, types of faults and cause.

Course Description: This course discusses on need, quality and protective schemes relays, construction and working principle of types relays overcurrent protection and types of fault power system. Analyzing the working of distance relays and the effects of arc resistance, power swings, distance and source impedance on performance of distance relays. Analyzing the working of differential relays an application over transformer and generator protection.

Course Objectives:

1. To understand the need, essential quality relays, components of a protection system and classification of protective schemes.
2. To explain the operating principles and construction of electromechanical relays, static relay and numerical relay.
3. To explain the operating principles and construction of Over current relay, types and Protective Schemes.
4. To understand Distance Protection scheme and types of relays used for distance protection.
5. To understand differential relay protection schemes for transformer and generator.
6. To understand the construction and working of circuit breaker and range of application.

Course Outcomes:

COs	After the completion of the course the students will be able to	Blooms level	Descriptor
CO1	To understand the need, essential quality relays, components of a protection system and classification of protective schemes. Circuit breaker and range of application.	II	Understand
CO2	To Identify the type of relay for over current protection and their operating principles and construction.	IV	Applying
CO3	Analyzing the working of distance relays and the effects of arc resistance, power swings, distance and source impedance on performance of distance relays.	IV	Analyzing
CO4	Analyzing the working of differential relays an application over transformer and generator protection.	IV	Analyzing

PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1				2										1
CO2				4										1
CO3				4										1
CO4				5										1

Assessments:

Teachers' assessment-

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) andone End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content. (Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weight-age for course content. (Normally last three modules covered after MSE.)

Course Contents: **Unit 1: Introduction to Protective Relaying System-** Need for protective System, Essentialqualities of protection, Classification of protective relays, types of faults, classification of protective schemes.Components of a protection system, Zones of Protection, Primary and Back-up Protection, Current and voltage transformers for protection,CT burden calculation.	**6 Hrs.**
Unit 2: Relay- Basic Terminology of relay, Classification of Relay,Operating Principles and construction of Electromechanical attraction relays, Induction relays, Permanent magnet moving coil relay, Thermal relay. Digital relay-Static relay and Numerical Relay.	**6 Hrs.**
Unit3:Over-Current Protection of Transmission Lines- Over current relay and types, Overcurrent Protective Schemes. Induction type non directional over current relay.Analysis of relay operating time-PSM, TSM.Induction type directional relay over current relay, directional Earth fault relay, Protection of Parallel Feeders, Protection of Ring Mains, Earth Fault and Phase Fault Protection.	**6Hrs.**
Unit 4:Distance Protection- Introduction to Distance Protection, Impedance relay, induction type impedance relay, Reactance Relay, Mho Relay, Comparison between distance relay. Effect of Arc Resistance on the Performance of Distance Relays, Reach of Distance Relays. Effect of Power Swings on Performance of Distance Relays, Effect of Line Length and Source Impedance on Performance of Distance Relays.	**6Hrs** .
Unit 5: Differential Protection- Introduction, Simple Differential Protection, Zone of Protection of the Differential Relay, Percentage Differential Relay, voltage balanced differential relay, Differential Protection of Transformers, Differential Protection of generator- Various Faults and Abnormal Operating Conditions, Stator Faults-Stator Phase and Ground Faults,Transverse Differential Protection, and rotor faults.	**6Hrs.**
Unit 6:Circuit Breaker- Introduction to circuit breaker, Arc phenomena,methods of arc extinction, factor affecting active recovery voltage, derivation of restriking and rate of raise of recovery voltage (RRRV) and numerical. Resistance switching, Current Chopping. Circuit breaker rating, types, application. Bulk and Minimum Oil circuit breaker, Air break and air blast circuit breaker, Vacuum Circuit Breakers,	**6Hrs.**

SF6 Circuit Breakers.	

Textbooks				
1	Power System Protection and Switchgear	Badri Ram, D.N. Vishwakarma	McGraw Hill	2nd Edition
2	Fundamentals of Power System Protection	Y. G. Paithankar, S. R. Bhide	Prentice-Hall of lndia Private Limited	1st Edition
3	Power System Protection and Switchgear	BhuvaneshAjitramOza	McGraw Hill	1st Edition
Reference books				
1	Switchgear and Protection	Sunil.S. Rao,	Khanna Publications	1st Edition

Unit wise Measurable students Learning Outcomes:

At the end of the course the student will be able to:

1. To explain the need, essential quality relays, components of a protection system and classification of protective schemes.
2. To explain the operating principles and construction of electromechanical relays, static relay and numerical relay.
3. To explain the operating principles and construction of Over current relay, types and Protective Schemes.
4. To analyze distance protection scheme and types of relays used for distance protection.
5. To analyze differential relay protection schemes for transformer and generator.
6. To explain the construction and working of circuit breaker and range of application.

Title of the Course : Electric Vehicles Technologies	L		P	Credit
Course Code:UELC0502	04	-	-	04

Course Pre-Requisite: Basic knowledge about electric motors, batteries, power electronics.

Course Description: This course discusses the fundamental concepts and analysis of hybrid and electric vehicles. This course discusses the various EV subsystems such as electric motors, energy storage devices, charging technology etc. Analytical exercises in vehicle dynamics, battery parameters and charging technology are included as a preparatory base for designing an EV.

Course Objectives: To impart the knowledge about electric vehicles and hybrid vehicles. To expose the Electrical Engineering students to various interdisciplinary areas related to electric and hybrid vehicles.

Course Outcomes:

COs	After the completion of the course the students will be able to	Blooms level	Descriptor
CO1	Explain thecorrelation between hev,EV and environment, infrastructure and policies of a nation.	II	Understand
CO2	Explain the performance parameters of various subsystems in EV.	II	Understand
CO3	Explain the role of various subsystems and components in EV and HEV	II	Understand
CO4	Calculate the performance parameters of EV subsystems	IV	Analyzing

PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO01	PSO02
CO1			1	1		1	1					2	2	3
CO2	1	2	2	1		1	1					2	2	2
CO3	3	2		2		1	1					2	2	2
CO4	3	3		2		1	1					2	2	2

Assessments:

Teachers' assessment-

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content.(Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weight-age for course content. (Normally last three modules covered after MSE.)

Course Contents: **Unit 1: Fundamentals of vehicles and powertrains:** History of fall and rise of electric vehicles, ICEV – power train operation and the need of gears and clutch, (numerical treatment) EV-powertrain, introduction to HEV, comparison between ICEV, HEV, EV, Vehicle terminology and architectures. Subsystems in different types of vehicles.	**8 Hrs**
Unit2: Vehicle dynamics: dynamic performance features of the vehicle, traction force components and their calculations. Factors affecting the components, Traction power, energy consumed, fuel efficiency, Drive cycle, examples of drive cycles.	**8 Hrs.**
Unit3: Hybrid Electric Vehicle: hybridization of energy sources, hybridization of propelling devices, Goals and challenges in HEV design, degree of hybridization, classification based on degree of hybridization and the features therein, hybrid drive-train topologies- series, parallel (), series-parallel, complex hybrid. power flow in various modes.	**8 Hrs.**
Unit 4: Motors forElectric Vehicle and their control:construction, working and speed control of BLDCM, SM, Induction M, Switched reluctance M, synchronous rel M, axial flux motor, Concept of MTPA, trapezoidal bipolar drive for BLDCM, unipolar drive for SRM, introduction to vector control of IM and Syn M	**9Hrs.**
Unit 5: Energy Storage for Electric vehicles: Battery performance parameters and design of battery pack (numerical treatment), Li ion cell- structure, varieties of Li ion battery and comparison between them, otheradvanced batteries for EV, structure and working of Fuel Cell energy storage, Super Capacitor, Necessity of hybridization of energy sources, Ragone plot.	**9Hrs.**
Unit 6:Charging technology: CV charging, CC charging, terminology, conductive Charging technologies, charging standards in India, connectors, Concepts of inductive charging, V2G, V2V charging, battery swapping and bulk charging, impact of uncontrolled fast charging on grid, charging protocols. EV policies and schemes of Indian government.	**7 Hrs.**

1	Tom Denton	"Electric and Hybrid Vehicles"	Routledge, 2016
2	C.C.Chau and K.T. Chau	Modern Electric Vehicle Technology	OXJORD UNIVERSITY PRESS
3	Ali Emadi	Advanced Electric Drive Vehicles	CRC press, 2014
Reference books			
1	M. Ehsani, Y. Gao, S. E. Gay and A. Emadi,	"Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design"	CRC Press, 2004
2	Chris Mi, M. A. Masrur and	"Hybrid Electric Vehicles: Principles	John Wiley & Sons, 2011

	D. W. Gao	and Applications with Practical Perspectives"		
3	S. Onori, L. Serrao and G. Rizzoni	"Hybrid Electric Vehicles: Energy Management Strategies"	Springer, 2015	
4	JiuchungJuaing, CaipingZhang	Funda& Appl of Li-ion Bat in Electric Drive Vehicles-	Wiley publications, 2015	

Unit wise Measurable students Learning Outcomes:

At the end of the course the student will be able to:

1. Recall the basic terms and architecture of vehicles.
2. Explain the components of traction force.
3. Compare various types of HEVs.
4. Explain the working of various types of motors used in EV.
5. Recall various battery parameters.
6. Explain various charging techniques and standards.

Other Books and references:

1. K. T. Chau, Electric vehicle Machines and drives Design, analysis and application, Wiley

2. C. C. Chan, K. T. Chau - Modern Electric Vehicle Technology, Oxford University Press, (only contents available)

3. Electric Powertrain Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles John G Hayes, G Abas Goodrazi , John Wiley & Sons

4. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press,

5. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley

6. NITI Aayog handbook on charging infrastructure, 2022

7. NITI Aayog Annual reports.

8. S. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies", Springer, 2015

Title of the Course : Microcontrollers Course Code:UELC0503	L	T	P	Credit
	04	-	-	04

Course Pre-Requisite: Knowledge of numbering systems and Boolean algebra. Knowledge of combinational and sequential logic circuits.

Course Description: This course discusses internet of things ,its architecture ,connectivity, interfacing and application.

Course Objectives: To make the students aware of

1. Explain the microcontroller architecture & describe the features of a typical microcontroller.
2. To use the 8051 addressing modes and instruction set and apply this knowledge to develop programs in assembly language and C language.
3. To define the protocol for serial communication and understand the microcontroller development systems.
4. Explain the interrupt structure of the microcontroller and to develop programs related to interrupt handling
5. To provide students with interfacing concepts and develop interfacing circuits for simple devices.

Course Outcomes:

COs	After the completion of the course the students will be able to	Blooms level	Descriptor
CO1	To summarize the architecture and features of various types of the microcontroller.	II	Understanding
CO2	To illustrate addressing modes and execute programs in assembly language for the microcontroller..	IV	Analyzing
CO3	To write programs in C language for microcontroller 8051.	III	Apply
CO4	To elaborate interrupt structure of 8051 and program to handle interrupt and ADC809.	II	Understanding
CO5	To interface the input output devices and measure electrical parameters with 8051 in real time.	III	Apply

PO MAPPING

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

Assessments:

Teachers' assessment-

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content.(Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weight-age for course content. (Normally last three modules covered after MSE.)

Course Contents: **Unit 1:Introduction to concept of microcontroller** Intel 8051 Functional block diagram, Functions of pins of 8051, Memory organization of 8051, PSW and Flag Bits, Stack and Stack pointer.Overview of special function registers,Data transfer instructions and programs in assembly language.	**7 Hrs.**
Unit 2:Instruction Set 8051 Arithmetic and logical instructions and programs in assembly language.Boolean and Program Branching instructions and programs in assembly language.Addressing modes of 8051.	**8 Hrs.**
Unit 3: Programming of 8051& Timers in 8051 8051 Programming in C , Data types in C . Ports of 8051, their use, and programming in C (Byte Level and Bit-level). Time delay programming in C. Timers and counters in 8051, Timer modes 0,1,2 and its programming in C and counter programming.	**8 Hrs.**
Unit 4: Interrupts Interrupt structure of 8051 and SFR associated with interruptsProgramming of External hardware interrupts in C.Interfacing of ADC 0809 with 8051.	**9Hrs.**
Unit 5: Serial Communication in 8051 Serial port Structure in 8051. Programming of Serial port for transferring and receiving data in C in mode 1. Introduction to GSM module, AT commands, Programming to send and read SMS.	**09Hrs.**
Unit 6:Intefacing with 8051 Measurement of electrical parameters such as voltage, current (Theoretical Treatment only). Interfacing of Stepper motor with 8051 and its programming in C.Interfacing and programming of single Key, LED, and Relay with 8051 in C.	**7Hrs.**

Texts books:

1. Muhammad Ali Mazidi, J.G. Mazidi, "The 8051 Microcontroller and Embedded Systems", Pearsons Publishers.
2. V Udayashankara and M S MallikarjunaSwamy, "8051 Microcontroller, Hardware, software and applications", TATA McGraw Hill.
3. Ajay Deshmukh, "Microcontroller 8051" –TATA McGraw Hill.
4. Theagrajan," Microprocessor and Microcontroller", BS Publication.

5. K. J. Ayala, "The 8051 Microcontrollers- Architecture, Programming and Applications", Peram International Publications.
6. SubrataGhoshal, "8051 microcontroller", Pearsons Publishers.
7. Han-Way Huang," Embedded System Design with C8051", Cengage Learning

ferences:

1. Scott Mackenzie, "8051 Microcontroller", Pearson Education.
2. Intel Microcontroller data book.
3. Intel Corporation 1990- 8 bit embedded controller handbook.

Unit wise Measurable students Learning Outcomes:

1. The students will be able to recall the features and architecture of 8051..
2. The students will be able to learn the instruction set of 8051.
3. The students will be able to write Assembly & C language programs on 8051.
4. The students will be able to understand the Interrupt structure of 8051.
5. The students will be able tounderstand the Serial Communication of 8051..
6. The students will be able to interface 8051 with external devices.

Title of the Course : Utilization of Electrical Energy *(Program Elective – I)* **Course Code: UELE0541**	**L**	**T**	**P**	**Credit**
	03	**-**	**-**	**03**

Course Pre-Requisite: Knowledge of Electrical Machines, Power Electronics and Drives and Power System.

Course Description:

This course primarily deals with utilization of electrical energy generated from various sources. It is important to understand the technical reasons behind selection of motors for electric drives based on the characteristics of loads. Electric heating, welding and illumination are some important loads in the industry in addition to motor/drives.

Course Objectives:

- This Course provides an introduction to the principles of electrical drives and their applications in daily life.
- This course provides basic knowledge of Heating and Welding.
- This course deals with the fundamentals of illumination and its classification.
- This course provides knowledge on electrical traction systems and their controlling.

Course Outcomes:

COs	**After the completion of the course the students will be able to**	**Blooms level**	**Descriptor**
CO1	To understand the operating principles and characteristics of traction motors with respect to speed, temperature, loading condition	I	Remember
CO2	To acquaint with the different types of heating and welding techniques	II	Understand
CO3	To study the basic principles of illumination and its measurement	III	Applying
CO4	To study the basic principles of electrolyte and its applications	III	Applying
CO5	To understand and analyze the basic principle of electric traction including speed–time curves of different traction services	IV	Analyze

PO MAPPING

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

CO5		2		3										2

Assessments:

Teachers' assessment-

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MSE: Assessment is based on 50% of course content.(Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weight-age for last three modules covered after MSE.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

Course Contents:

Unit 1: Electrical Drives: Type of electric drives, choice of motor, starting and running characteristics, speed control, temperature rise, particular applications of electric drives, types of industrial loads, continuous, intermittent and variable loads, load equalization, Applications of electrical motors in textiles mills, Mines cranes, Lifts, Excavators, Marine drives pumps, Refrigerators & air conditioning.	**8 Hrs.**
Unit 2: Electric Heating: Advantages of electrical heating, Resistance heating, Design of heating element in resistance oven, Control of temperature in resistance oven, Electric arc furnaces, Induction furnaces, Dielectric heating, Infrared heating and Microwave heating	**6 Hrs.**
Unit 3: Electric Welding: Advantages of Electric Welding, welding methods, principle of resistance welding, types – spot, projection seam and butt welding, welding equipment used, principle of arc production, electric arc welding, characteristics of arc, carbon arc, metal arc, hydrogen arc welding, Modern welding techniques like Ultrasonic & Laser welding.	**6 Hrs.**
Unit 4: Illumination: Requirement of good lighting, Classification of light fitting & luminaries, Factor to be considered for design of indoor & outdoor lighting scheme, Design procedure for factory lighting, flood lighting & street lighting, Discharge lamps, MV and SV lamps comparison between tungsten filament lamps and fluorescent tubes, Basic principles of light control. .	**8 Hrs.**
Unit 5: Electrolyte process: Need of electro-deposition, process of electro deposition-clearing, operation, deposition of metals, polishing, buffing, equipment and accessories for electroplating, factor affecting electro deposition, principle of galvanizing and its applications, principle of anodizing and its applications, electroplating on non conducting materials.	**6 Hrs.**

Unit 6: Electrical Traction System: Different systems of traction, Advantages & disadvantages, Systems of track electrification, Speed-time curve, Tract effort, Adhesive weight, Coefficient of adhesion, Specific energy consumption, Power supply arrangements, Current collecting systems, Desirable characteristics of traction motors, Suitable motors for traction, Control of D.C. traction motors, Shunt transition, Bridge transition, Regenerative braking, Study of performance, operation & metering system, D.C. & A. C. transition.	**10 Hrs.**

Texts and references:

1. Taylor E. O., 'Utilisation of Electrical Engineering', Longman.
2. Partab H. P., 'Art & Science of Utilisation of Electrical Engineering' Dhanpat Rai Publications.
3. Gupta J. B., 'Utilization of Electric Power & Electric Traction' S. K. Kataria & Sons.
4. Uppal S. L., 'Electrical Power', Khanna Book Publication.

Unit wise Measurable students Learning Outcomes:

1. To understand the operating principles and characteristics of traction motors with respect to speed, temperature, loading condition.
2. Analyze Electric heating for Industrial application.
3. Demonstrate electric welding for industrial application.
4. To study the basic principles of illumination and its measurement
5. To study of different applications of electrolyte process.
6. To understand the method of calculation of various traction system for braking, acceleration and other related parameters, including demand side management.

Title of the Course: Electrical Energy Management *(Program Elective – I)* **Course Code: UELC0542**	**L**	**T**	**P**	**Credit**
	03	**--**	**-**	**03**

Course Pre-Requisite: Knowledge of power and energy in three phase and single phase circuit, common electrical equipments, power generation techniques.

Course Description:

This course aims to stress on the importance of energy saving and the methodological approach to achieve the same. It includes the diverse areas such as energy management, demand management, energy audit and the financial impact of these processes.

Course Objectives:

1. To understand prominence of energy and energy security.
2. Understand effect Audifor energy resources on surroundings and release standards, different operating frame work.
4. Learn several tools of Demand Control.
3. Calculate economic viability of energy saving option.

Course Outcomes:

COs	**After completion of the course the students will be to**	**Bloom's Level**	**Descriptor**
CO1	**Clarify** the principles of energy management	II	Understanding
CO3	**Select** energy conservation methods for a given application	IV	Analyzing
CO2	**Execute** demand side management and source side management of a system	III	Applying
CO4	**Create** energy audit report for case studies	VI	Creating

CO-PO MAPPING

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

Assessments:

Teacher's assessment-

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.
ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weight-age for course content.(Normally last three modules) covered after MSE.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

Course Contents:

Unit I:---Energy Importance Classification of Energy resources, Commercial and non-commercial energy, primary and secondary sources, commercial energy production, Energy needs of a system with growing economy, short term and long term energy policies, energy sector reforms, distribution system reforms and up-gradation, energy security, importance of energy conservation, energy and environmental impacts, emission check standard, green building code, Global Climate Change Treaty, Kyoto Protocol, Clean Development Mechanism, salient features of Energy Conservation Act 2001 Indian and Global energy scenario.	**6 Hrs.**
Unit II:---Energy Management Definition and Objective of Energy Management, Principles of Energy management, Energy Management Strategy, Energy Manager Skills, key elements in energy management, force field analysis, energy policy, format and statement of energy policy, Organization setup and energy management. Responsibilities and duties of energy manager under act 2001. Energy Efficiency Programmes. Energy monitoring systems.	**6Hrs.**
Unit III:---Demand Management Supply side management (SSM), various measures involved such as use of FACTS, VAR Compensation, Generation system up gradation, constraints on SSM. Demand side management (DSM), advantages and Barriers, implementation of DSM, areas of development of demand side management in agricultural, domestic and commercial consumers. Demand management through tariffs (TOD). Power factor penalties and incentives in tariff for demand control. Apparent energy tariffs. Role of renewable energy sources in energy management, direct use (solar thermal, solar air conditioning, biomass) and indirect use (solar, wind etc.).	**8Hrs.**
Unit IV:---Energy Audit Definition, need of energy audit, types of audit, procedures to follow, data and information analysis, energy audit instrumentation, energy consumption – production relationship, pie charts. Sankey diagram, Cusum technique, least square method and numerical based on it. Outcome of energy audit and energy saving potential, action plans for implementation of energy conservation options. Bench- marking energy performance of an industry. Energy Audit Report writing as per prescribed format. Audit case studies of sugar, steel, paper and cement industries.	**8 Hrs.**

Unit V:---Energy Conservation in Applications: Motive power (motor and drive system). b) Illumination c) Heating systems (boiler and steam systems) c) Ventilation(Fan, Blower, Compressors) and Air Conditioning systems d) Pumping System e) Cogeneration and waste heat recovery systems f) Utility industries (T and D Sector) g) Diesel generators.	**6 Hrs.**
Unit VI:---Financial Analysis and Case Studies Costing techniques; cost factors, budgeting, standard costing, sources of capital, cash flow diagrams and activity chart. Financial appraisals; criteria, simple payback period, return on investment, net present value method, time value of money, break even analysis, sensitivity analysis and numerical based on it, cost optimization, cost of energy, cost of generation, Energy audit case studies such as IT sector, Textile, Municipal corporations, Educational Institutes, T and D Sector and Thermal Power stations.	**8Hrs.**

Textbooks:

1. Utilization of electrical energy by S.C. Tripathi, Tata McGraw Hill.
2. Energy Management by W.R. Murphy and Mackay, B.S. Publication.
3. Generation and utilization of Electrical Energy by B.R. Gupta, S. Chand Publication.
4. Energy Auditing made simple by Balasubramanian, Bala Consultancy Services.
5. Guide books for National Certification Examination for Energy Managers/Energy Auditors Book 1, General Aspects (available on line)
6. Guide books for National Certification Examination for Energy Managers/Energy Auditors Book 2 – Thermal Utilities (available on line)
7. Guide books for National Certification Examination for Energy Managers/Energy Auditors Book 3- Electrical Utilities (available on line)
8. Guide books for National Certification Examination for Energy Managers/Energy Auditors Book 4 (available on line)

References:

1. Success stories of Energy Conservation by BEE (www. Bee-india.org)
2. Utilization of electrical energy by S.C. Tripathi, Tata McGraw Hill.
3. Energy Management by W.R. Murphy and Mackay, B.S. Publication.
4. Generation and utilization of Electrical Energy by B.R. Gupta, S. Chand Publication.
5. Energy Auditing made simple by Balasubramanian, Bala Consultancy Services.

Websites:

1. www.energymanagertraining.com
2. www.em-ea.org
3. www.bee-india.org
4. www.pcra.org

Unit wise Measurable students Learning Outcomes:

After completion of the course students will be able to:

1. Analyze and understand energy consumption patterns.
2. Analyze Environmental impacts and mitigation method.
3. List various energy conservation measures for various processes..
4. Conduct Preliminary energy audits.
5. Choose a convenient economic feasibility of energy conservation option.

Title of the Course :Solar photovoltaic systems *(Open Elective I)* **Course Code:UELO0581**	**L**	**T**	**P**	**Credit**
	04	**-**	**-**	**04**

Course Pre-Requisite: Knowledge of semiconductor physics,basics of electrical engineering

Course Description: This course discusses the fundamentals, design and application of solar photovoltaic systems for power generation on small and large scale electrification.

Course Objectives: To make the students aware of

1.To learn principles of solar energy conversion principle.
2.To understand basics of photo voltaic cell .
3. To design PV systems for various applications.
4.To understand socio-economic and environmental merits of photovoltaic systems for a variety of applications.

Course Outcomes:

COs	**After the completion of the course the students will be able**	**Blooms level**	**Descriptor**
CO1	To understand principle of direct solar energy conversion to power using PV technology.	II	Understanding
CO2	To summarize structure, materials and operation of solar cells, PV modules, and arrays.	II	Understanding
CO3	To conceptually design PV systems for various applications.	III	Apply
CO4	To analyze prospects of photovoltaic technology for sustainable power generation.	IV	Analyzing

PO MAPPING

CO	**PO 1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1														
CO2														
CO3														
CO4														
CO4														1

Assessments:

Teachers' assessment-

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content.(Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weight-age for course content. (Normally last three modules covered after MSE.)

Course Contents: **Unit 1: Solar Cell Fundamentals:**Photovoltaic effect - Principle of direct solar energy conversion into electricity in a solar cell. Semiconductor properties, energy levels, basic equations. Solar cell, p-n junction, structure.	**07 Hrs.**
Unit 2: PV module performance: I-V characteristics of a PV module, maximum power point, cell efficiency, fill factor, effect of irradiation and temperature.	**07 Hrs.**
Unit 3: Manufacturing of pv cells : Commercial solar cells - Production process of single crystalline silicon cells, multi crystalline silicon cells, amorphous silicon, cadmium telluride, copper indium gallium diselenide cells.	**08 Hrs.**
Unit 4: Design of pv systems: Design of solar PV systems and cost estimation. Case study of design of solar PV lantern, stand alone PV system - Home lighting and other appliances, solar water pumping systems.	**08 Hrs**
Unit 5: Classification of pv systems and components: Classification - Central Power Station System, Distributed PV System, Stand alone PV system, Grid Interactive PV System, small system for consumer applications, Hybrid solar PV system, Concentrator solar photovoltaic. System components - PV arrays, inverters, batteries, charge controls, net power meters. PV array installation, operation, costs, reliability.	**09Hrs.**
Unit 6: PV system applications Building-integrated photovoltaic units, grid-interacting central power stations, standalone devices for distributed power supply in remote and rural areas, solar cars, aircraft, space solar power satellites. Socio-economic and environmental merits of photovoltaic systems.	**09Hrs.**

Texts books:

1) Internet of Things: Architecture, Design Principles, Raj Kamal, McGraw Hill Education (India) Pvt. Limited, 2017.Advanced power Electronics and A.C. Drives: B.K. Bose
2) Foundational Elements of an IOT Solution - The Edge, Cloud and Application Development, Joe Biron& Jonathan Follett, Oreilly, First Edition, March 2016
3) Designing Connected Products, 1st Edition, Elizabeth Goodman, Alfred Lui, Martin Charlier, Ann Light, Claire Rowland.
4) The Internet of Things (A Look at Real World Use Cases and Concerns), Kindle Edition, 2016, Lucas Darnell.

References:

1)Designing the Internet of Things, Adrian Mc Ewen and Hakim Cassimally, Wiley, First edition, 2013.
2) Getting Started with the Internet of Things, Cuno P fister, O'reilly, 2011.
3) Internet of Things : A Hands-on Approach, Arshdeep Bahga, and Vijay Madisetti, 2014.

Unit wise Measurable students Learning Outcomes:

1The students will be able to learn the various fundamentalsof solar photovoltaics.
2The students will be able to analyse the photovoltaic module performnace.
3.The students will be able to choose photovoltaic cells used for commercial purpose.
4.The students will be able to learn and analyze photovoltaic cells design.
5.The students will be able to classify pv systems and its components.
6.The students will be able to analyze the implementation of IOT from the case studies like Smart Home, Smart city.

Title of the Course : Renewable Energy Sources *(Open Elective I)* **Course Code:UELO0582**	**L**	**T**	**P**	**Credit**
	03	**--**	**--**	**03**

Course Pre-Requisite: Conventional Energy Environmental Sciences,Environmental aspects of electric power generation from conventional sources.

Course Description: As the demand for electrical energy is ever-increasing. Developing renewable energy sources has become very important. This course introduces two renewable resources – solar and wind. The students will explore some of the science, mathematics, and technology used to extract energy from these renewable resources.

Course Objectives:

1. To explain the basic features of Solar and Wind energy.
2. To analyze the characteristics of PV module and Wind energy conversion System.
3. To design PV system and Wind Energy conversion system.

Course Outcomes:

COs	After completion of the course the students will be to	Bloom's Level	Descriptor
CO1	**Explain** the basic features of Solar and Wind energy.	II	Understanding
CO2	**Analyze** the characteristics of PV module and Wind energy conversion System.	IV	Analyzing
CO3	**Design** PV system and Wind Energy conversion system	VI	Creating

PO MAPPING

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	3			1		2	2					1		
CO 2	3						2					2	2	1
CO 3	3	3	3	3	2								3	2

Assessments:

Teacher's assessment-
Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weight-age for course content.(Normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Introduction to Renewable Energy Sources Global and Indian scenario of RES, need for alternative energy sources, advantages & disadvantages of RES, classification of RES & comparison, key factors affecting RES.	**4 Hrs.**
Unit 2:--- Solar Energy Solar thermal power generation, history, solar photovoltaic power generation, basics of PV cell, materials used for PV cell, efficiency of PV cell, equivalent electrical circuit, open circuit voltage and short circuit current, I-V & P-V curves, effects of different electrical parameters on I-V & P-V curves, measurement of solar insolation, solar concentrator, flat plate &concentrating collectors.	**8 Hrs.**
Unit 3:--- Solar Photovoltaic Energy Conversion & Utilization Configuration of PV power generation system- off-grid system & grid-connected PV system, single stage & two stage converters for power transfer, single phase & three phase inverters for PV, control of grid connected PV system.	**8 Hrs.**
Unit 4:--- Wind Energy Introduction, Basic Principles of Wind Energy Conversion, Wind Energy Scenario – World and India. The Nature of the Wind, the Power in the Wind, Forces On the Blades, Wind Energy Conversion, Wind Data and Energy Estimation, Site Selection Considerations Wind Energy Systems:Environment and Economics Environmental Benefits and Problems of Wind Energy, Economics of Wind Energy, Factors Influence the Cost of Energy Generation.	**8 Hrs.**

Unit 5:---Components of a Wind Energy Conversion System: Wind Turbines Types: Vertical Axis Type, Horizontal Axis, Constant Speed Constant Frequency, Variable Speed Variable Frequency, Up Wind, Down Wind, Stall Control , Pitch Control, Gear Coupled Generator Type, Direct Generator Drive /PMG/Rotor Excited Sync Generator Wind Turbine Technology & Components Of WTG 1) Gear Coupled Generator Type [Const. Speed] 2) Direct Coupled Generator Type [Variable Speed Variable Frequency]: Multi Pole Synchronous / PMG Generators. 3) Doubly Fed Induction Generator and Power Control	**8 Hrs.**
Unit 6:--- Analysis of Wind Energy Conversion System & Energy Estimates: Instrumentation for wind measurements, Wind data analysis, tabulation, Wind resource estimation, Betz's Limit, Turbulence Analysis. Power coefficient & tip speed ratio characteristicsAerodynamics Theory: Airfoil terminology, Blade element theory, Blade design, Rotor performance and dynamics, Balancing technique (Rotor & Blade), Types of loads; Sources of loads. Energy Storage, Applications of Wind Energy.	**6Hrs.**

Textbooks:

1. Boyle, Godfrey, "Renewable Energy", (2nd edition), Oxford University Press, 2004.
2. G. S. Sawhney, "Non-Conventional Resources of Energy", PHI Publication 2012.

References:

1. Gary-L. Johnson Wind Energy Systems Tata Mc-Graw-Hill Book Company.
2. James Manwell, J. F. Manwell Wind Energy Explained: Theory, Design and Application.
3. Paul Gipe Wind Power, Renewable Energy for Home, Farm, and Business.

Unit wise Measurable students Learning Outcomes:

After completion of the course students will be able to:

1. Explain the various renewable energy sources.
2. Compare the equivalent circuit of PV cell and its modeling.
3. Explain the structure and working of grid-connected PV system.
4. Explain wind power generation & its mechanical aspects.
5. Explain the smart grid, recent trends in renewable system & standards for grid integration.
6. Describe aerodynamics in WT & energy storage systems.

Title of the Course : AUDIT COURSE-III **NPTEL/CourseEra/MOOCS (Ehics/Enterpreneurship/Buisness Modelling)** **Course Code: UELA0561**	**L**	**T**	**P**	**Credit**
	-	**01**	**-**	**-**

Course Pre-Requisite: Skill Recognition**,** Entrepreneurship Awareness

Course Description: It is an audit course. Intention is to help students create entrepreneurship awareness through self learning.

Student should register for the online course of minimum 4 weeks offered by SWAYAM, NPTEL,Courseera or any other authorized platforms. Should be able to help students in the chosen career. The courses are to be approved by the committee appointed by the department. Student should complete the course and after the examination should produce a certificate.

Note: The students should preferably register for the course in consultation with coordinator, MOOCS. Students those who produce the grade certificate of authorized platforms will be exempted from the ESE examination and declared with satisfactory performance.

Assessments:

Teachers' assessment-

Course will be graded based on certificate credentials mentioned on the certificate by the authorized agency. Unless student produces the grade certificate to the department, the course will not be complete.

Title of the Course: Power System Protection Lab Course Code:UELC0531	L	T	P	Credit
	-	-	2	03

Course Pre-Requisite: Basic Knowledge Electric Power System, Electrical Power Generation, Transmission and Distribution. Working of Electric Machine, types of faults and cause.

Course Description: This course discusses on need, quality and protective schemes relays, construction and working principle of types relays over/under current protection, over/under voltage protection, and types of fault power system. Understand the working of Electromechanical, solid state and numerical relay.

Course Objectives:

1. To plot the IDMT characteristics of non-directional and directional over/under current electromechanical type relay.
2. To plot the DMT characteristics of Solid state and numerical relay for Over/under current and over /under voltage protection non-directional and directional electromechanical type relay.
3. To analyze the distance and directional protection scheme for transformer and generator.

Course Outcomes:

COs	After the completion of the course the students will be able to	Blooms level	Descriptor
CO1	To plot the IDMT characteristics of non-directional and directional over/under current electromechanical type relay.	IV	Analyzing
CO2	To plot the DMT characteristics of Solid state and numerical relay for Over/under current and over /under voltage protection non-directional and directional electromechanical type relay.	IV	Analyzing
CO3	To distinguish the distance and directional protection scheme for transformer and generator.	III	Applying

PO MAPPING

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

Assessments:
Teachers' assessment-

List of Experiments:	
1. Non-Directional Electromagnetic Over Current Relay Characteristics.	**2 hours**
2. Directional Electromagnetic Over Current Relay Characteristics.	**2 hours**
3. Operating Characteristics of Solid State Over Voltage Relay.	**2 hours**
4. Operating Characteristics of Solid State Under Voltage Relay.	**2 hours**
5. Microprocessor Based (Numeric) Over Current Relay Characteristics.	**2 hours**
6. Microprocessor Based (Numeric) Under Current Relay CharacteristicsVoltage Relay.	**2 hours**
7. Microprocessor Based (Numeric) Over Voltage Relay Characteristics.	**2 hours**
8. Microprocessor Based (Numeric) Under Voltage Relay Characteristics.	**2 hours**
9. Protection of Induction Motor using numerical relay.	**2 hours**
10. Generator Protection or Transformer protection.	**2 hours**

Experiment wise Measurable students Learning Outcomes:

At the end of the course the student will be able to:

1. To plot the IDMT characteristics of Non-Directional Electromagnetic Over Current Relay.
2. To plot the IDMT characteristics Directional Electromagnetic Over Current Relay.
3. To plot the Operating Characteristics of Solid State Over Voltage Relay.
4. To plot the Operating Characteristics of Solid State Under Voltage Relay.
5. To plot the Operating Characteristics Microprocessor Based (Numeric) Over Current Relay Characteristics.
6. To plot the Operating Characteristics Microprocessor Based (Numeric) Under Current Relay Characteristics Voltage Relay.
7. To plot the Operating Characteristics Microprocessor Based (Numeric) Over Voltage Relay Characteristics.
8. To plot the Operating Characteristics Microprocessor Based (Numeric) Under Voltage Relay Characteristics.
9. To apply protection scheme for Induction Motor using numerical relay.
10. To apply protection scheme for Protection of Generator protection or Transformer

Title of the Course : Electric Vehicles Technology Laboratory Course Code:UELC0532	L	T	P	Credit
	-	-	02-	01

Course Pre-Requisite: Basic knowledge about vehicle dynamics, battery, MATLAB simulink.

Course Description: This course deals with vehicle architecture, analysis of performance features of various subsystems in a vehicle. The course contains experimentation and simulation to test, control and design certain subsystems in EV.

Course Objectives: To impart the knowledge about electric vehicles.
To expose the Electrical Engineering students to design and testing aspects of Electric Vehicles.
To develop the skills to evaluate the performance of electric motor
To develop the skills to analyze battery performance and design of a battery.
To develop the skills to analyze effect of vehicle design paramaters on its performance.

Course Outcomes:

COs	After the completion of the course the students will be able to	Blooms level	Descriptor
CO1	To evaluate the technique of speed control of an electric motor	III	Apply
CO2	To testthe effect of parameters of vehicle design on its performance.	V	Evaluate
CO3	To evaluate performance parameters of a battery.	V	Evaluate

PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO01	PSO02
CO1		3	3	3	2				3	2		2	1	3
CO2		3	3	3	2				3	2		2	1	3
CO3		3	3	3	2				3	2		2	1	3

Assessments:
Teachers' assessment-
Includes In Semester Evaluation (ISE) and one End Semester Examination (ESE)

Assessment	Marks
ISE	25
ESE	50

ISE assessmentis based on performing the experiments and submitting the journal. This will be done every week as and when the experiment is performed.
ESE: Assessment is based on oral examination on 100% course content. It is done after completion of all

experiments.

Course Contents:	
Experiment No.1: Architecture and subsystems in ICE driven vehicles	**2 Hrs.**
Experiment No.2: Architecture and subsystems in Electric vehicles	**2 Hrs.**
Experiment No.3: Speed control of BLDC motor	**2 Hrs.**
Experiment No.4: Measurement of battery parameters during charging and discharging	**2 Hrs.**
Experiment No.5: Effect of gradient on traction force needed to maintain a certain velocity.	**2Hrs.**
Experiment No.6: Effect of air velocity on speed of a vehicle	**2 Hrs.**
Experiment No.7: Calculation of fuel efficiency of an EV undertaking certain drive cycle.	**2 Hrs.**
Experiment No. 8: Study and testing of electric charger	**2 Hrs.**
Experiment No.9: Visit to a charging substation	**2 Hrs.**
Experiment No.10: Single phase single PWM generator	**2 Hrs.**
Experiment No.11: Three phase multiple PWM generator	**2 Hrs.**
Experiment No.12: Battery cell balancing	**2 Hrs.**

Textbooks				
1	Tom Denton	"Electric and Hybrid Vehicles"	Routledge, 2016	
2	Ali Emadi	Advanced Electric Drive Vehicles	CRC press, 2014	
Reference books				
1	M. Ehsani, Y. Gao, S. E. Gay and A. Emadi,	"Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design"	CRC Press, 2004	
2	Chris Mi, M. A. Masrur and D. W. Gao	"Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives"	John Wiley & Sons, 2011	
3	JiuchungJuaing, CaipingZhang	Funda& Appl of Li-ion Bat in Electric Drive Vehicles-	Wiley publications, 2015	

	4.	NPTEL	MOOC on Fundamentals of Electric Vehicle-Technology and Economics	Sep-Dec2020	

Experiment wise Measurable students Learning Outcomes:

At the end of the course the student will be able to:

Experiment No.1: Identify various parts in ICE driven vehicles
Experiment No.2: Identify various parts in Electric vehicle
Experiment No.3: Control speed of BLDC motor
Experiment No.4: Measure battery parameters during charging and discharging
Experiment No.5: Plot the graph of traction force versus road gradient.
Experiment No.6: Plot the graph of vehicle speed versus air velocity.
Experiment No.7: Calculate fuel efficiency of an EV undertaking certain drive cycle.
Experiment No. 8: Test signals at various test points in an electric charger
Experiment No.9: List ratings of charging substation and connectors.
Experiment No.10: Generate single PWM signal for single phase bridge inverter.
Experiment No.11: Generate three phase multiple PWM signal for 3 phase bridge inverter.
Experiment No.12: Study Battery cell balancing techniques.

Title of the Course : Microcontroller Lab Course Code: UELC0533	L	T	P	Credit
	-	-	02	01

Course Pre-Requisite: Digital Electronics

Course Description: This course discusses the CPU architecture and programming concepts with assembly language and C compiler.

Course Objectives:

1. This course is designed to develop the necessary skills required for programming 8051microcontrollers to implement real world applications.
2. The course aims at understanding the practical problems in electrical systems and implementing programs for same.
3. This course introduces various programming softwares to implement 8051 microcontroller based applications.

Course Outcomes:

COs	After the completion of the course the student will be able to	Blooms level	Descriptor
CO1	**Utilize** simulation tools to analyze microcontroller based systems.	III	Applying
CO2	**Apply** programming techniques to implement counters, timers, interrupts and other peripherals**.**	III	Applying
CO3	**Implement** the applications related to interfacing of microcontroller to electrical and electronics systems.	III	Applying
CO4	**Apply** programming techniques to microcontroller other than 8051.	III	Applying
CO5	**Design** electrical applications using microcontrollers.	VI	Creating

PO MAPPING

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

Assessments:

Teachers' assessment-

Includes In Semester Evaluation (ISE) and one End Semester Examination (ESE)

Assessment	Marks
ISE	25
ESE	50

ISE: Assessment is based on performing the experiments and submitting the journal. This will be done every week as and when the experiment is performed.

ESE: Assessment is based on performance and oral examination
Course Contents: Perform minimum 13 experiments from the following list.
Experiment 1: ---- To perform block transfer& block exchange operation using 8051.
Experiment 2:---To separate even & odd numbers using 8051
Experiment 3:---To find the smallest and largest number using 805
Experiment 4: ----To perform arithmetic and logical operations using 8051.
Experiment 5:--- To interface stepper motor interfacing with 8051.
Experiment 6: --- To interface DAC with 8051.
Experiment 7: ---- To interface LED/thermal sensors with microcontrollers other than 8051
Experiment 8: ---- To study Serial Communication programming using 8051.
Experiment 9: ---- To perform Port programming using 8051.
Experiment 10:-----To generate square wave using Timer in 8051.
Experiment 11:-----To interface of the relay with 8051.
References: 1. '8051 Architecture, Programming and Applications', Kenneth Ayala. 2. MykePredko, 'Programming and customizing the 8051 microcontroller', TATA McGraw Hill. SubrataGhoshal, 'Embedded Systems and Robots- Projects using the 8051 Microcontroller', Cengage Learning.
Experiment wise Measurable students Learning Outcomes:
Experiment 1 :-The student will be able to perform data transfer, arithmetic & logical operations using 8051
Experiment 2 :-The student will be able to separate even and odd numbers using 8051.
Experiment 3 :- The student will be able to determine smallest and largest number using 8051
Experiment 4 :- The student will be able to perform arithmetic and logical operations using 8051.
Experiment 5 :- The student will be able to interface stepper motor interfacing with 8051.
Experiment 6 :- The student will be able to interface DAC with 8051
Experiment 7 :-The student will be able to interface LED with 8051 microcontroller.
Experiment 8 :-The student will study the serial communication programming using 8051
Experiment 9 :-The student will be able to generate square wave using timers in 8051.
Experiment 10 :-The student will be able to perform port programming using 8051

Experiment 11:-The student will be able to interface relay using 8051

Title of the Course :Mini Project-II	**L**	**T**	**P**	**Credit**
Course Code: UELC0534	**-**	**-**	**02**	**01**

Course Pre-Requisite: Smart Grid, Electric Vehicle, Wireless Power Transmission, Artificial Intelligence, Energy Saving Lighting Technologies, Internet of Things (IOT), Sustainable Energy, Energy Storage and Battery Management, Robotics.

Course Description:

This lab prepares students to develop thinking process to solve social problems by application of science and engineering in innovative manner. The group of students not more than 3 should identify social problems, perform requirement analysis. After interactions with course coordinator and based on comprehensive literature survey/need analysis, the student shall identify the title and define the aim and objectives of micro-project. As per requirements the group should develop specifications of final outcome of the project. The students should think critically and undertake design of the project with skills available with them to meet the requirements and specifications. The group is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and submit the proposal within first week of the semester. The student is expected to exert on design, development and testing of the proposed work as per the schedule. The working model of the project will be demonstrated for internal submission. Completed micro project and documentation in the form of micro project report is to be submitted at the end of semester. The project should complete in 12 weeks including field trails if any. At the end of project the guide should advise students to protect Intellectual Property either in the form of Patent or registration of design or publish paper on work completed or participate in project competition.

Course Objectives:

1. **Identify** the problem statement.
2. **Understand** the methodology to troubleshoot the small circuit
3. **Convert** idea in to product.
4. **Work** in a group to implement the idea.
5. **Communicate** effectively to present theme of mini-project.

Course Outcomes:

COs	After completion of the course the students will be to	Bloom's Level	Descriptor
CO1	**Apply** the knowledge of advanced Electric and Electronic fundamental for problem definition.	IV	Analyzing
CO2	**Develop** methodology to troubleshoot circuit.	IV	Analyzing
CO3	**Test** the outcomes for desired results.	V	Evaluating
CO4	**Work** in groups to assemble Mini Project circuits.	V	Evaluating
CO5	**Demonstrate** presentation skills through Mini Project report.	IV	Analyzing

CO-PO MAPPING

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO 2
CO1	3	3	2	3	2	2	2	1					3	3
CO2	3	3	2	3	2	2	2	1					3	3
CO3	2	3	3	3	3				1			2	2	3
CO4	1	2			2			2	3	2	3	3	2	2
CO5		2			2			2	3	2	3	3	2	2

Assessments:

Teachers' assessment-

In Semester Evaluation (ISE), and End Semester Examination (ESE) having 50%weightage each

Assessment	Marks
ISE	50

ISE is based on performance of student in laboratory, experimental write-up, presentation, oral, and test (surprise/declared/quiz).

Course Contents:

- Environment protection, global warming, safe drinking water, waste management, renewable energy utilities, biomedical engineering, accident prevention, enabling weaker section of society, efficiency/cost/ time improvements, human hardship reduction, prosthesis, smart city, smart transportation, energy audit and saving.
- Students should form groups of maximum four in respective practical batch.
- Mini project should be a working model based upon their knowledge, understanding and practices.
- Evaluation of mini project will be through presentation, demonstration and report writing.

1. Smart Grids

Unlike in the past, whereby consumers solely depended on a local electrical power company, today, they have many options. With the ability to even generate their own power, some consumers also now want to sell their surplus. As a result, the electricity delivery infrastructure has to change. In response to these demands, most Energy Departments around the world are placing smart devices throughout their networks, right up to customers' homes, offices, and factories. The smart grid collects valuable data to allow both consumers and suppliers a higher degree of control over multiple power sources. It also enables them to predict surges in usage and instantly detect outages. By allowing end-to-end communication between distribution sites, power plants, and the end user's electrical point-of-presence, smart grids significantly raise efficiency and reduce costs. Soon, it's inevitable that electrical engineers will frequently come across smart grids and or be asked to help develop one.

2. Electric Vehicle

Tesla recently hit the $100 billion milestone, making itself the first publicly listed US carmaker in history to do so. This is a good sign that electric vehicles have come to stay. Experts predict that by 2030, there would be over 125 million electric vehicles on the road. Considering the millions of EVs that are already roaming the streets, this is not so much of a long-short. Many EV manufacturers are investing hard into the tech, and consumers can expect better batteries, improved charging tech, more accurate autonomous driving, solar-powered EVs, and even electric planes.

3. Wireless Power Transmission

Wireless power transfer is in its primitive stages, but the future is bright. In future, we expect better wireless charging for laptops, smart phones, earphones, and other smart devices. Shortly, however, we expect much more. Soon, wireless charging will also become the standard for electric cars. Instead of the large charging docks, drivers will be able to park on a charging spot without needing to plug in. Expects predict that a few years from now, it will also be possible to charge your electric vehicle while it's moving.

4. Artificial Intelligence

If artificial intelligence has penetrated large industries like armaments and medicine, surely the Electrical Engineering landscape cannot be an exception. Electrical Engineers are expected to do much better with AI. By blending their prowess and skill with the know-how of AI and machine learning, electrical engineers are contributing the following:

- Create complex algorithms for data interpretation
- Generate new codes or revamping existing codes
- Build massive AI and machine learning platforms
- Develop comprehensive strategies in the field of electronics

Most notably, artificial intelligence is going to help electrical engineers with image processing. Leveraging AI, engineers can invent complex image processing algorithms to help machines detect electrical or structural

abnormalities on a framework and quickly send feedback or suggest rectifications. Ultimately, this helps to improve the workplace safety of electrical engineers who are often involved in hazardous and massive electronic production lines.

5. **Energy Saving Lighting Technologies**

Gone are the days when LED bulbs were only for those willing to pay the top dollar. LED lamps are becoming the standard de facto light bulb. Today, with prices as low as Rs 150/- per bulb or even less, LED bulbs are now possibilities for the average consumer. Due to their energy-saving capabilities, the bulbs pay for themselves in a matter of months. On average, they can save each household Rs 3000 to Rs 5000 per year in utility bills. With more advances in smart technology, these lights are expected to become even more efficient and easy to install in the near future.

6. **Internet of Things (IOT)**

IoT impacts many different areas of the electrical engineering landscape. From smart grids to smart lighting and Visible Light Communication (VLC), among many others, IoT is now interlinked with the Electrical Engineering industry. As a result, it's now imperative that every electrical engineer becomes "IoT literate." Apart from the smart grid benefits like monitoring, distribution and automation implemented in electrical utilities, IoT applications in the field of electrical energy also include smart inverters, advanced metering infrastructure (AMI), remote control operation of energy-consuming devices and SCADA (supervisory control and data acquisition.)

7. **Sustainable Energy**

With Scientist making their firm stand for intense action towards climatic change, it's certainly not the best time for the energy sector to rely on fossil fuels and other environmentally unfriendly energy sources. The drive for sustainable energy sources is at its peak. The implementation of utility-scale renewable fuels such as solar, wind, and hydropower is, at its peak increase all around the world.

8. **Energy Storage and Battery Management**

While wind and solar power are excellent sources of sustainable energy, they are not always there. Therefore, consumers can only "make hay when the sun shines." They have to do their best to save energy from the wind, the sun, or any other renewable sources for later use. To meet this demand, Electrical Engineers all around the world are working towards better batteries and energy storage. Distributed Energy Resource (DER), grid parity, AI and sustainable energy, block chain, and cyber security. Generally, 2020 is an exciting year for the electrical engineering landscape.

9. **Robotics**

While robotics-based technologies are often ridiculed for stealing people's jobs in most industries, it's a different case in electrical engineering. Robotics significantly helps to improve safety. For instance, remotely controlled, wireless underground cable cutters can be used instead of putting humans at life-threatening risk.

Experiment wise Measurable students Learning Outcomes:

1. The students will develop sensitivity towards advanced social problems.
2. The students will be able to develop thinking process to solve advanced social problems by application of Science and engineering in innovative manner.
3. The students will be able to think critically and undertake design of the project with skills.
4. The students will be able to design, develop and test any assigned work.

Title of the Course: Industrial Drives and Control **Course Code:UELC0601**	**L**	**T**	**P**	**Credit**
	03	**-**	**-**	**03**

Course Pre-Requisite: Basic Knowledge Mechanical System, Electrical Machines and Power Electronics.

Course Description: This course discusses various electric drives, their operating modes, performance and applications.

Course Objectives: To make the students aware of

1. The concept and configuration of electric drives.
2. The dynamics and operational modes of electric drives.
3. Process of selection of a motor for a specific application.
4. Performance analysis of induction motor drives.
5. Control Techniques of various motor.

Course Outcomes:

COs	**After the completion of the course the students will be able to**	**Blooms level**	**Descriptor**
CO1	Understand the Parts of Electrical drives, Industrial Application, and dynamics of Electrical Drives	III	Applying
CO2	Analyze the Closed loop torque, speed control and Phase-locked-loop (PLL) control.	IV	Analyzing
CO3	To analyze the performance of DC motor drives using single phase and three Phase full and Half controlled converter.	IV	Analyzing
CO4	To analyze the performance of induction motor drives VSI, CSI and FOC control and special purpose motor drives.	IV	Applying

PO MAPPING

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

Assessments:

Teachers' assessment-

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content. (Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weight-age for course content. (Normally last three modules covered after MSE.)

Course Contents: **Unit 1: Basics of Electrical Drives and Control:** Definition Electrical drives, Types, Advantages of electrical drives, Parts of Electrical drives, Choice of electrical drives for typical applications, Status of DC and AC drives. Industrial Drives Application-Textile Mills, Steel Rolling Mills, Cranes and Hoists, Machine Tools.	**6 Hrs.**
Unit 2: Dynamics of Electrical Drives: Fundamental Torque Equations, Speed Torque Conventions and Multi-quadrant Operation. Equivalent Values of Drive Parameters, Components of Load Torques, Nature and Classification of Load Torques, Steady State Stability, Load Equalization.	**6 Hrs.**
Unit 3: Control of Electrical Drives: Concept of Constant torque control, constant power control, role of a gear in conventional drive and the concept of elimination of gear in electrical drive. Modes of the operation, speed control and drive classification, close loop control of drives. Closed loop torque control, Closed loop speed Control, Closed loop speed Control of multi motor drives, speed sensing, current sensing, Phase-locked-loop (PLL) control,	**7 Hrs.**
Unit 4: DC Motor Drives: Multi-quadrant operation of separately excited DC Shunt and DC Series motor using single phase and three Phase full controlled and half controlled converter. Dual converter fed DC Drives. Chopper controlled DC motor drives, Performance and stability of variable speed DC drives, Regenerative breaking the DC Motor.	**7Hrs.**
Unit 5: Control of Induction Motor Drives: Voltage Fed inverter (VSI) control, Open loop V/F Control, Speed control with torque and flux control. Current Fed inverter control (CSI), Independent Current and Frequency control. Speed and flux control in Current fed inverter drive, V/F Control in Current fed inverter drive. Vector or field-oriented control, principle of vector control, Direct or feedback vector control, Indirect or feed forward Vector Control.	**9Hrs.**

Unit 6: Special Purpose Motor Drives: Important Features of Permanent Magnet AC (PMAC) Motor Drives, Sinusoidal PMAC Motor Drives, and Brushless DC Motor Drives. Important Features of Stepper Motors, Torque Versus Stepping Rate Characteristics, Drive Circuits for Stepper Motor.	**6 Hrs.**

Texts and references:

1) Fundamentals of the electrical drives: Gopal K Dubey, Narosa publication
2) Advanced power Electronics and A.C. Drives: B.K. Bose
3) Electrical Drives Concept and application: Vedam Subrahnyam
4) Analysis of thyristor power conditioned motors: S.K.Pillai

Unit wise Measurable students Learning Outcomes:

1. Explain Parts of Electrical drives, Choice and Industrial Applications.
2. Explain dynamics and different modes of operation of electric drives.
3. Explain the Concept of Constant torque and speed control.
4. Apply Control concept of DC Motor Drive.
5. Apply Control concept of AC Motor Drive.
6. Explain the Special Purpose Motor Drives:

Title of the Course: Power System Analysis	L	T	P	Credit
Course Code: UELC0602	4	-	-	4

Course Pre-Requisite: Basic Knowledge of electrical power system and protection of power system.

Course Description: This course discusses the concepts of power system operation, analysis techniques & its stability.

Course Objectives:

1. To introduce the per unit system and explain its advantages and computation.
2. To explain the necessity and conduction of short circuit analysis.
3. To explain analysis of three phase symmetrical faults on synchronous machines.
4. To explain symmetrical components, their advantages and the calculation of symmetrical components.
5. To explain formulation of network models and bus admittance matrix for solving load flow problems.
6. To explain formulation of bus impedance matrix for the use in short circuit studies on power systems.
7. To explain numerical solution of swing equation for stability analysis.

Course Outcomes:

CO	After the completion of the course the student should be able to	Blooms level	Descriptor
CO1	**Understand** per unit system, its advantages and computation	II	Understanding
CO2	**Perform** short circuit analysis on a synchronous machine and simple power system to select a circuit breaker for the system	V	Design
CO3	**Evaluate** symmetrical components of voltages and currents in un-balanced three phase circuits	V	Apply
CO4	**Analyze** three phase synchronous machine and simple power systems for different unsymmetrical faults using symmetrical components.	VI	Analyse
CO5	**Explain** formulation of network models and bus admittance matrix for solving load flow problems.	VI	Analyse
CO6	**Discuss** the dynamics of synchronous machine, stability and types of stability.	III	Understanding

CO-PO Mapping:

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

Assessment Scheme:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and **ISE 2** are based on Assignment/Declared test/Quiz/Seminar/Group discussions/presentation, etc.
MSE is based on 50% of course content (first three units).
ESE is based on 100% course content with 60-70% weightage for course content (last three units) covered after MSE.

Course Contents

Unit No.	Unit Title and Contents	Hours
1	**Unit 1: Representation of Power System Components** Introduction, Single-phase Representation of Balanced Three Phase Networks, One-Line Diagram and Impedance or Reactance Diagram, Per Unit (PU) System, Steady State Model of Synchronous Machine, Power Transformer, Transmission of electrical Power, Representation of Loads.	**06**
2	**Unit 2: Symmetrical Fault Analysis** Introduction, Transient on a Transmission Line, Short Circuit of a Synchronous Machine(On No Load), Short Circuit of a Loaded Synchronous Machine, Selection of Circuit Breakers.	**06**
3	**Unit 3: Symmetrical Components** Introduction, Symmetrical Component Transformation, Phase Shift in Star-Delta Transformers, Sequence Impedances of Transmission Lines, Sequence Impedances and Sequence Network of Power System, Sequence Impedances and Networks of Synchronous Machine, Sequence Impedances of Transmission Lines, Sequence Impedances and Networks of Transformers, Construction of Sequence Networks of a Power System, Measurement of sequence Impedance of Synchronous Generator.	**06**
4	**Unit 4: Unsymmetrical Fault Analysis** Introduction, Symmetrical Component Analysis of Unsymmetrical Faults, Single Line-To-Ground (LG) Fault, Line-To-Line (LL) Fault, Double Line-To-Ground (LLG) Fault, Open Conductor Faults.	**06**
5	**Unit 5: Load Flow Studies** Introduction, Network Model Formulation, Formation of $Ybus$ by Singular Transformation, Load Flow Problem, Gauss-Seidel Method, Newton-Raphson Method, Decoupled Load Flow Methods, Comparison of Load Flow Methods.	**06**
6	**Unit 6: Power system stability** Power System Stability: Introduction, Dynamics of a Synchronous Machine, Power Angle Equation Salient and Non – Salient pole Synchronous Machines, Simple Systems, Steady State Stability, Transient Stability, Equal Area Criterion, Factors Affecting Transient Stability.	**06**

Textbooks:

Sr. No.	Title	Edition	Author/s	Publisher	Year
1	Modern Power system Analysis – by I.J.Nagrath & D.P.Kothari: Tata McGraw-Hill Publishing company, 2nd edition.	4th	I.J.Nagrath & D.P.Kothari	Tata McGraw-Hill Publishing company	2011
2	Power system Analysis Operation and control, Abhijit Chakrabarthi , Sunita Haldar, 3ed , PHI,2010.	2nd	Abhijit Chakrabarthi , Sunita Haldar,	PHI,2010	2010

Reference Books:

SN	Title	Edition	Author/s	Publisher	Year
1	Elements of Power System	4th	William D. StevensonJr	McGraw Hill.	1982
2	Power System Analysis and Design	4th	J.Duncan Glover et al	Cengage	2008
3	Power System Analysis	1st	Hadi Sadat	McGraw Hill.	2002

Unit wise Measurable Students Learning Outcomes:

1. The students will be to understand basic concept of per unit system.
2. The students will be to circuit breaker based on symmetrical fault analysis in power system.
3. The Students will be able to convert unbalanced voltage and currents into balanced phasors using symmetrical transformation method.
4. The students will be able to carry out unsymmetrical fault analysis for different types of shunt and series faults in power system.
5. The students will be to apply different iterative techniques for power flow studies.
6. The students will be discuss equal area criterion for the evaluation of stability of a simple system under different fault conditions.

Title of the Course: IOT Electrical Engineering Course Code: UELC0603	L	T	P	Credit
	04	-	-	04

Course Pre-Requisite: Knowledge of Embedded system, Programming concept

Course Description: This course discusses internet of things its architecture, connectivity, interfacing and application.

Course Objectives: To make the students aware of

1. To understand fundamentals, architecture and various technologies of Internet of Things.
2. To impart knowledge on the infrastructure, sensor technologies and networking technologies of IoT.
3. To explore the entrepreneurial aspect of the Internet of Things.
4. To know the connectivity of devices using web and internet in the IoT environment.
5. To know various data acquisition methods, data handling using cloud for IoT applications.
6. To understand the implementation of IoT by studying case studies like Smart Home, Smart city.

Course Outcomes:

COs	After the completion of the course the students will be able to	Blooms level	Descriptor
CO1	learn fundamentals, architectures and technologies of Internet of Things.	II	Understanding
CO2	To interface physical devices through Arduino.	IV	Analyzing
CO3	To understand various data acquisition methods, data handling using cloud for IoT applications	III	Apply
CO4	To analyze the implementation of IOT from the case studies	IV	Analyzing

PO MAPPING

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

Assessments:

Teachers' assessment-

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content.(Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weight-age for course content. (Normally last three modules covered after MSE.)

Course Contents: **Unit 1: Introduction to Internet of Things:** Definition and characteristics of IoT, Difference between IoT and IIoT, Evolution of IoT and the trends, Impact of IoT on businesses and society, Existing IoT use cases and applications across industries, Analysis of security and privacy risks, Privacy standards and regulations.	**8 Hrs.**
Unit 2: Architecture of IoT: Physical design of IoT, Logical design of IoT-Functional blocks, Communication models, Communication Application Programming Interfaces (API), Basics of Networking including Wireless Sensor Networks, Cloud Computing, Sensor-Cloud.	**8 Hrs.**
Unit 3: Hardware Associated with IoT: Sensors, Transducers and Actuators, Special requirements for IoT and IIoT sensors, Humidity sensors, Ultrasonic sensor, Temperature sensor, Arduino, Raspberry Pi, Communication Protocols-HART, MODBUS, Serial and Parallel, Ethernet, BACNet, Sensors Networks, Integration of sensors and actuators with Arduino.	**8 Hrs.**
Unit 4: Software associated with IoT: Introduction to Software Defined Networking (SDN), SDN for IoT, Data handling and analytics. Challenges in IoT – Design and Challenges, Development challenges, Security challenges and Other Challenges.	**7Hrs.**
Unit 5: IoT and Machine to Machine (M2M): M2M, Difference and similarities between IoT and M2M, Network function virtualization (NFV), Difference between SDN and NFV for IoT.	**6Hrs.**
Unit 6: IoT Solutions and Applications: Roadmap for developing complete IoT solutions, Strategies for implementation, Scalability of IoT solutions, Methods platforms and tools, Web and Mobile Interfaces, Applications of IoT in Lighting services, Intelligent Traffic systems, Smart parking systems, Smart water management.	**6Hrs.**

Texts books:

1) Internet of Things: Architecture, Design Principles, Raj Kamal, McGraw Hill Education (India) Pvt. Limited, 2017.
2) Foundational Elements of an IOT Solution - The Edge, Cloud and Application Development, Joe Biron& Jonathan Follett, Oreilly, First Edition, March 2016
3) Designing Connected Products, 1st Edition, Elizabeth Goodman, Alfred Lui, Martin Charlier, Ann Light, Claire Rowland.
4) The Internet of Things (A Look at Real World Use Cases and Concerns), Kindle Edition, 2016, Lucas Darnell.

ferences:

1) Designing the Internet of Things, Adrian McEwen and Hakim Cassimally, Wiley, First edition, 2013.
2) Getting Started with the Internet of Things, CunoPfister, O'reilly, 2011.
3) Internet of Things: A Hands-on Approach, ArshdeepBahga, and Vijay Madisetti, 2014.

Unit wise Measurable students Learning Outcomes:

1. The students will be able to learn the various fundamentals, architectures and technologies of Internet of Things.
2. The students will be able to Understand the design architecture of IOT.
3. The students will be able to choose protocols and deployment in solutions.
4. The students will be able to understand various data acquisition methods, data handling using cloud for IoT applications.
5. The students will be able to interface physical devices through Arduino.
6. The students will be able to analyze the implementation of IOT from the case studies like Smart Home, Smart city.

Title of the Course : Power Quality and Harmonics	**L**	**T**	**P**	**Credit**
(Program Elective-II) **Course Code: UELE0641**	**3**	**--**	**--**	**3**

Course Pre-Requisite: Basic knowledge of power electronics, power system harmonics, power system is required

Course Description: Electrical Power System is really a very complex network. Pure power includes sinusoidal stable voltages and currents. In reality due to various reasons the power quality is deteriorated. In this course, some basics of power quality with harmonics mitigation techniques are studied.

Course Objectives:

1. To explain the basics of Power Quality and Harmonics
2. To analyze the harmonics mitigation techniques
3. To study the Power Quality Analyzer for harmonics measurement

Course Outcomes:

COs	**After completion of the course the students will be to**	**Bloom's Level**	**Descriptor**
CO1	**Explain** the basic features of Power Quality & Harmonics.	II	Understanding
CO2	**Comprehend** the voltage sag measurement & mitigation techniques	II	Understanding
CO3	**Analyze** the harmonics measurement technique.	IV	Analyzing

PO MAPPING

CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO 1	3	3		1		1						1	1	1
CO 2	3	3	2	1	2	1						2	1	1
CO 3	3	3	1	1	3		1	1				1	2	3

Assessments:

Teachers' assessment-

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weight-age for course content.(Normally last three modules) covered after MSE.

Course Contents:

Unit 1:---Introduction to Power Quality Desired feature of Electrical Power Supply, Power Quality related issues in distribution systems, loads and theirs characteristics, electromagnetic phenomena, voltage sags/swells, waveform distortions, unbalance, flicker, notches, unbalance and load balancing	**7Hrs.**
Unit 2:--- Fundamental of Harmonics Causes for generation of harmonics, effect of harmonic on systems, types and characterization of Harmonics, THDs, influence on power factor, interference with communication network and harmonic indices.	**7Hrs.**
Unit 3:---Harmonics Suppression Filters Shunt Passive Filters, Design Considerations and case studies, Voltage / Current Source active filters, types: shunt, series and Hybrid Filter, their characteristics and comparison.	**7Hrs.**
Unit 4:--- Mitigation of Voltage Sag and interruptions End user issues, UPS systems, Ferro resonant Transformers, Super Conducting Storage Devices, Dynamic Voltage Restorer and Application of DSTATCOM.	**7Hrs.**
Unit 5:---Harmonic Measurement Instrumentation techniques, Analog and Digital Methods, presentation of Harmonic data and interruption, case studies, Harmonic Standard and future trends**.**	**7Hrs.**
Unit 6:--- Power Quality Monitoring Power Quality Analyzer, Acceptability of Power Supply- tolerance envelops of CBEMA and ITIC, reliability indices, typical wiring and grounding problems, grounding practices and use of signal reference grid	**7 Hrs.**

Textbooks:

1. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.Wayne Beaty, 'Electrical Power Systems Quality' McGraw Hill, 2003.
2. Dr. Mahesh Kumar, IIT Chennai, Power Quality in Distribution Systems.
3. A. Ghosh and G. Ledwich, Power Quality Enhancement using Custom Power Devices. Boston, MA: Kluwer, 2002. .

References:

1. J. Arrillaga, N.R. Watson, S. Chen, 'Power System Quality Assessment', (New York: Wiley, 1999).
2. G.T. Heydt, 'Electric Power Quality', 2nd Edition. (West Lafayette, IN, Stars in a Circle Publications, 1994).
3. George J. Wakileh, "Power System Harmonics - Fundamentals, Analysis & filter Design" Springer.
4. M.H.J Bollen, 'Understanding Power Quality Problems: Voltage Sags and Interruptions', (New York: IEEE Press, 1999).
5. Angelo Baggini, Handbook on Power Quality, John Wiley & Sons, New Jersey, USA, 2008.

Unit wise Measurable students Learning Outcomes:

After completion of the course students will be able to:

1. Learn to distinguish between the various categories of power quality problems.
2. Understand the root of the power quality problems in industry and their impact on performance and economics..
3. Learn to apply appropriate solution techniques for power quality mitigation based on the type of problem.
4. Introduce the importance of grounding on power quality.
5. Introduce power distribution protection techniques and its impact on voltage quality.
6. Explain the function of power quality analyzer

Title of the Course : Flexible AC Transmission Systems *(Program Elective-II)* **Course Code: UELE0642**	**L**	**T**	**P**	**Credit**
	03	**--**	**-**	**03**

Course Prerequisites: Knowledge about Power System Engineering, Power Electronics.

Course Description:
To impart the students with various FACTS devices which are used for proper operation of existing AC System. This course introduces the application of a variety of high power-electronic controllers for active and reactive power in transmission lines. Students are exposed to the basics, modeling aspects, control and scope for different types of FACTS controllers.

Course Objectives:
1. To make students understand concept of FACTs envisages the use of power electronics to improve system operation by fast & reliable control.
2. To cover concepts of FACTs including the description, principle of working and analysis of various FACTs controllers.
3. To strengthen the control of FACTs and system interactions.

Course Outcomes:

COs	After completion of the course the students will be to	Bloom's Level	Descriptor
CO1	**Explain** necessity, operating principals and benefits of FACTs devices.	II	Understanding
CO2	**Demonstrate** series and shunt compensation using FACTS devices.	III	Applying
CO3	**Examine** the concept of UPFC and IPFC.	IV	Analyzing

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	2	3	3			2					2	2	2
CO2	3	2	3	3			2					2	2	2
CO3	3	2	3	3			2					2	2	2

Assessments:

Teachers' assessment-
Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weight-age for course content.(Normally last three modules) covered after MSE.

Course Contents:

UNIT-I : Introduction to FACTS Transmission Interconnections, Why We Need Transmission Interconnections, Opportunities for FACTS, Flow of Power in an AC System , Power Flow in Parallel Paths , Power Flow in Meshed System, Limits of the Loading Capability, Power Flow and Dynamic Stability Considerations of a Transmission Interconnection, Relative Importance of Controllable Parameters.	**07 Hrs**
UNIT-II : Types of FACT Controllers Basic Types of FACTS Controllers, Relative Importance of Different Types of Controllers, Brief Description and Definitions of FACTS Controllers , Shunt Connected Controllers, Series Connected Controllers , Combined Shunt and Series Connected Controllers, Benefits from FACTS Technology.	**06 Hrs**
UNIT-III : Static Shunt Compensators Objectives of Shunt Compensation, Midpoint Voltage Regulation for Line Segmentation, End of Line Voltage Support to Prevent Voltage Instability, Improvement of Transient Stability, Power Oscillation Damping, Summary of Compensator Requirements, Methods of Controllable Var Generation, Variable Impedance Type Static Var Generators, The Thyristor-Controlled Reactor (TCR), Operating Characteristics of a TCR, The Fixed Capacitor–Thyristor-Controlled Reactor (FC–TCR), The Thyristor-Switched Capacitor (TSC), The Thyristor-Switched Capacitor–Thyristor-Controlled Reactor (TSC–TCR), SVC and STATCOM, Comparison Between STATCOM and SVC.	**08 Hrs**
UNIT-IV: Static Series Compensators Objectives of Series Compensation, Concept of Series Capacitive Compensation, Voltage Stability , Improvement of Transient Stability, Power Oscillation Damping, Sub synchronous Oscillation Damping, Summary of Functional Requirements, Approaches to Controlled Series Compensation, Variable Impedance Type Series Compensators , GTO Thyristor-Controlled Series Capacitor (GCSC), Thyristor- Switched Series Capacitor (TSSC), Thyristor-Controlled Series Capacitor (TCSC), Sub synchronous Characteristics , Basic Operating Control Schemes for GCSC, TSSC and TCSC.	**08 Hrs**

UNIT-V : Static Voltage and Phase Angle Regulators Static Voltage and Phase Angle Regulators: Objectives of Voltage and Phase Angle Regulators, Approaches to Thyristor-Controlled Voltage and Phase Angle Regulators, Switching Converter-Based Voltage and Phase Angle Regulators	**06 Hrs**
UNIT-VI : Combined Compensators: Unified Power Flow Controller (UPFC) and Interline Power Flow Controller (IPFC) Introduction, The Unified Power Flow Controller: Basic operating principle, Conventional Transmission Control Capabilities, Independent Real and Reactive Power Flow Control, Control Structure, The Interline Power Flow Controller (IPFC): Basic Operating Principles and Characteristics, Control Structure, Applications.	**07 Hrs**

Text Books:

1. Narain G.Hingorani, Laszio. Gyugyi, Understanding FACTS Concepts and Technology of Flexible AC Transmission System, Standard Publishers, Delhi, 2001.
2. K. R. Padiyar "FACTS CONTROLLERS in Power Transmission & Distribution," New Age International (P) Ltd.," 2007.

References:

1. A.T. John, Flexible AC Transmission System, Institution of Electrical and Electronic Engineers (IEEE), 1999.
2. R. Mohan Mathur, Rajiv. K. Varma, Thyristor – Based Facts Controllers for Electrical Transmission Systems, IEEE press and John Wiley & Sons Inc., 2002.
3. Vijay K. Sood "HVDC and FACTS Controllers: Applications of Static Converters in Power Systems", Kluwer academic publisher, 2004.

Useful Link:

https://nptel.ac.in/courses/108107114

Unit wise Measurable students Learning Outcomes:

1. The students will be able to understand basics of FACTS technology.
2. The students will be able study different types of FACT Controllers.
3. The students will be able analyze different types of Shunt compensators.
4. The students will be able analyze different types of Series compensators.
5. Student will understand voltage regulation of transmission line with Static Voltage and Phase Angle Regulators.
6. The students will be able to study Combined Compensators.

Title of the Course : Electric and Hybrid Vehicles *(Open Elective-II)* **Course Code:UELO0681**	**L**		**P**	**Credit**
	04	**-**	**-**	**04**

Course Pre-Requisite: Basic knowledge about electric motors, batteries, power electronics.

Course Description: This course discusses the fundamental concepts, principles, analysis and design of hybrid and electric vehicles. This course discusses the various EV subsystems such as electric motors, motor controllers, energy storage devices, battery management system, charging technology etc. Analytical exercises in case studies based on a suitable open source software will be carried out.

Course Objectives: To impart the knowledge about electric vehicles and hybrid vehicles. To expose the students to various drive technology and energy storage technology required in electric and hybrid vehicles.

Course Outcomes:

Cos	**After the completion of the course the students will be able to**	**Blooms level**	**Descriptor**
CO1	Recall the impact of EV on environment and sustainability	II	Understand
CO2	Compare different drive trains in Electric and Hybrid Vehicles	II	Understand
CO3	Compare different energy storage devices.	II	Understand
CO4	Analyze the performance of EV subsystems.	IV	Analyzing

PO MAPPING

CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO2**
CO 1	3					3	3							1
CO 2	3	2												1
CO 3	3			2										1
CO 4	3	3		2									1	1

Assessments:

Teachers' assessment-

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content.(Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weight-age for course content. (Normally last three modules covered after MSE.)

Course Contents: **Unit 1: Introduction and vehicle dynamics**: History of conventional vehicles, hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, Basics of vehicle dynamic performance, transmission characteristics, mathematical models to describe vehicle performance, Indian drive cycle and modified Indian drive cycle. Fuel efficiency analysis	8 Hrs
Unit2:Hybrid Electric Vehicle: Operation of ICE driven Vehicles, Basic concept of hybrid traction, introduction to various hybrid drive-train topologies and the operation, power flow control in hybrid drive-train topologies,	8 Hrs.
Unit 3: Electric Vehicle Drive-trains: Battery operated electric vehicles, EV subsystems, introduction to various electric drive train topologies, power flow control in electric drive-train topologies, Configuration and controllers for BLDC Motor drives, SM drives, induction motor drives, drive system efficiency	9Hrs.
Unit 4: Energy Storage for Electric vehicles: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery and its performance analysis, Li ion battery and future batteries for EV, Introduction to Fuel Cell based energy storage , Super Capacitor based energy storage , Flywheel based energy storage. Hybridization of different energy storage devices	9Hrs.
Unit 5 :Battery pack design: Electrical, mechanical, thermal and BMS design of battery pack.	8Hrs.
Unit 6: Energy Management: Charging technology and infrastructure, classification and comparison of different energy management strategies, implementation issues. EV policies of Indian government.	5Hrs.

Textbooks				
1	C. Mi, M. A. Masrur and D. W. Gao	, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives",	John Wiley & Sons, 2011	
2	S. Onori, L. Serrao and G. Rizzoni	"Hybrid Electric Vehicles: Energy Management Strategies",	, Springer, 2015	
Reference books				
1	M. Ehsani, Y. Gao, S. E. Gay and A. Emadi,	, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design"	CRC Press, 2004	
2	T. Denton,	"Electric and Hybrid Vehicles"	Routledge, 2016	

Unit wise Measurable students Learning Outcomes:

At the end of the course the student will be able to:

1. Recall the basics of vehicle performance.
2. Recall the basics hybrid vehicle drive-train topologies.
3. Compare the performance of various motors and controllers .
4. Calculate battery performance parameters.
5. Recall the major issues in designing a battery pack.
6. Compare different energy management strategies

Title of the Course : Electric Motors & Its Control **Course Code: UELO0682** *(Open Elective-II)*	**L**	**T**	**P**	**Credit**
	03	**-**	**-**	**03**

Course Pre-Requisite: Knowledge of basic electrical engineering & Power Electronics is required.

Course Description: This course discusses working of various electrical motors and their different control methods.

Course Objectives:

- To explain the different types of electrical motors.
- To analyze the characteristics of different DC & AC motors.
- To understand the different drives used for the control of AC & DC motors.

Course Outcomes:

COs	**After the completion of the course the students will be able to**	**Blooms level**	**Descriptor**
CO1	Explain the construction & working of DC & AC motors.	II	Understanding
CO2	Analyze the characteristics & performance of DC & AC Motors	III	Applying
CO3	Explain the selection of motor power rating to suit industry requirements	III	Applying
CO4	Analyze the performance & control of DC & AC motor drives.	IV	Analyze

PO MAPPING

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

Assessments:

Teachers' assessment-

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content.(Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weight-age for last three modules covered after MSE.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

Course Contents: **Unit 1: DC Motors:** Review of Magnetic Circuits and concepts of Electromagnetic Induction. Concept of back e.m.f., types, torque equation, speed equation, characteristics of D.C. motors, applications, electrical braking, Losses and efficiency, Testing & specifications of D.C. machines: Swinburn's test, Hopkinson's test, Field test on D.C. series motor. (Theoretical treatment only).	**8 Hrs.**
Unit 2: Three Phase Induction Motor: Construction, Types- cage type (single cage, double cage), slip ring type, operation, creation of rotating field, Torque equation, speed equation, speed torque curve, Review of different types of torques, equivalent circuit, power flow diagram, efficiency, starting and types of starters.	**6 Hrs.**
Unit 3: Synchronous Motors: Construction, Saliency: direct & quadrature operation axis, speed, torque, Method of starting, phasor diagram, torque angle equation, V –curves and inverted V-curves, hunting and damping, synchronous condenser.	**6 Hrs.**
Unit 4: DC Motor Drives: Single Phase Fully Controlled Rectifier Control of DC Separately Excited Motor, Single Phase Half Controlled Rectifier Control of DC Separately Excited Motor, Three Phase Fully Controlled Rectifier Control of DC Separately Excited Motor, Three Phase Half Controlled Rectifier Control of DC Separately Excited Motor, Multi-quadrant Operation of DC Separately Excited Motor Fed Form Fully Controlled Rectifier, Rectifier Control of DC Series Motor, Chopper Control of Separately Excited DC Motor, Chopper Controlof Series Motor.	**8 Hrs.**
Unit 5: Induction Motor Drives: Starting, Braking, Transient Analysis. Speed Control Techniques-Stator Voltage Control, Variable Voltage Frequency Control from Voltage Sources. Voltage Source inverter (VSI) control, Speed control with torque and flux control. Current Fed inverter control (CSI), Independent Current and Frequency control. Speed and flux control in Current fed inverter drive, V/F Control in Current fed inverter drive.	**8 Hrs.**

Unit 6: Synchronous Motor Drives: Operation from fixed frequency supply-starting, synchronous motor variable speed drives, variable frequency control of multiple synchronous motors. Self-controlled synchronous motor drive employing load commutated thyristor inverter, Starting Large Synchronous Machines,	**6 Hrs.**

Texts and references:

1. J. Nagrath and D. P. Kothari. "Electric Machines", McGraw Hill Education, 2010.
2. A.E. Clayton, "DC Machines", Mc Graw Hill publication, 3rd Edition.
3. B.L. Theraja, A. K. Theraja, S. Chand "A textbook of Electrical Technology, Vol I and Vol II"
4. S. K. Bhattacharya, "Electrical Machines", Tata Mc Graw Hill, New Delhi
5. J. B. Gupta, "Electrical Machines", S K Kataria and Sons, New Delhi.
6. Electrical Machines by Ashfaq Husain, Dhanpatrai & CO, Third Edition.
7. Fundamentals of the electrical drives by Gopal K Dubey-Narosa publication, 2nd Edition, 2001
8. Electrical Drives Concept and application by Vedam Subrahnyam, McGraw Hill, 2nd Edition, 2011.
9. Electric Drives by N.K De,P.K. Sen, PHI Learning, 1st Edition, 2009
10. Modern power Electronics and A.C. Drives by B.K. Bose, Prentice Hall PTR.

Unit wise Measurable students Learning Outcomes:

1. Explain different types of DC motors & their working..
2. Explain different types of Induction motors & their working.
3. Explain different types of Synchronous motors & their working.
4. Discuss various DC Motor Drives.
5. Discuss various Induction Motor Drives.
6. Discuss various Synchronous motors drives.

Title of the Course : AUDIT COURSE-IV **NPTEL/CourseEra/MOOCS (Advancements of Electrical Engineering)** **Course Code: UELA0661**	**L**	**T**	**P**	**Credit**
	01	**-**	**-**	**-**

Course Pre-Requisite: Basic Electrical Engineering**,** Power Electronics, Industrial Drives & Control

Course Description: It is an audit course. Intention is to help students create Electrical Engineering awareness through self learning.

Student should register for the online course of minimum 4 weeks offered by SWAYAM, NPTEL,Courseera or any other authorized platforms. Should be able to help students in the chosen career. The courses are to be approved by the committee appointed by the department. Student should complete the course and after the examination should produce a certificate.

Note: The students should preferably register for the course in consultation with coordinator, MOOCS. Students those who produce the grade certificate of authorized platforms will be exempted from the ESE examination and declared with satisfactory performance.

Assessments:

Teachers' assessment-

Course will be graded based on certificate credentials mentioned on the certificate by the authorized agency. Unless student produces the grade certificate to the department, the course will not be complete.

Title of the Course : Industrial Drives and Control Lab Course Code: UELC0631	L	T	P	Credit
	-	-	2	01

Course Pre-Requisite: Basic Knowledge of Power Electronics & Electrical Machines is desirable.

Course Description: In this course students will understand Control of various electrical motors with the help of different converters and simulate various electrical drives circuit using MATLAB to evaluation of their performance.

Course Objectives:

1. To get hands on experience in using power electronics drivers in controlling electrical machines.
2. To analyze performance of electrical machines with variation in control parameters.
3. To compare performance of various techniques of controlling the electrical motors.
4. To simulate various electrical drives circuits using MATLAB.

Course Outcomes:

COs	After the completion of the course the students will be able to	Blooms level	Descriptor
CO1	Compare the open loop and closed loop control of separately excited DC Motor	IV	Analyzing
CO2	Control the speed of Three phase induction motor using VFD and slip power recovery scheme.	III	Applying
CO3	Control speed of special purpose motors	III	Applying
CO4	Use model based design to evaluate performance of a electrical motor under controlled parameters	IV, V	Analyzing, Evaluate

PO MAPPING

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

Assessments:

Teacher's Assessment:-

In Semester Evaluation (ISE), and End Semester Examination (ESE) having weightage asfollows.

Assessment	Marks
ISE	25
ESE(OE)	50

ISE is based on at least two of the assessment tools like performance of student in laboratory, experimental write-up, presentation, oral, and test (surprise/declared/quiz). ESE Assessment is based on performance in practical conduction & oral at the end of the semester.

List of Experiments: Perform any 10 full experiments.	
1. Single phase fully controlled converter fed separately excited DC motor drive.	**2 hours**
2. Three phase half controlled converter fed separately excited DC motor drive.	**2 hours**
3. Three phase fully controlled converter fed separately excited DC motor drive.	**2 hours**
4. Dual converter fed separately excited DC motor drive.	**2 hours**
5. Chopper fed DC motor drive	**2 hours**
6. Inverter fed Three phase induction motor drive control using VFD.	**2 hours**
7. Speed control of three phase induction motor using slip power recovery scheme.	**2 hours**
8. Speed Control of special purpose Motors (BLDC/PMSM/SRM/Stepper motor)	**2 hours**
9. Simulation of single phase fully controlled converter fed separately excited DC motor drive.	**2 hours**
10. Simulation of Dual converter fed separately excited DC motor drive.	**2 hours**
11. Simulation of chopper fed DC motor drive.	**2 hours**
12. Simulation of 180 degree mode operation of inverter.	**2 hours**

Title of the Course: Power System Analysis lab Course Code: UELC0632	L	T	P	Credit
	-	-	2	1

Course Pre-Requisite: Basic Knowledge of electrical power system analysis.

Course Description: This course discusses the about different electrical software used for solving different power system problems

Course Objectives:

1. To develop primitive matrix required for power system analysis.
2. To do analysis for the power system network using load flow solutions methods.
3. To do symmetrical fault analysis in power system
4. To do unsymmetrical fault analysis in power system.

Course Outcomes:

CO	After the completion of the course the student should be able to	Blooms level	Descriptor
CO1	**Evaluate** Symmetrical components of unbalanced voltage and currents.	IV	Understanding
CO2	**Analyze** power system under Symmetrical fault and Unsymmetrical fault conditions.	V	Analyse
CO3	**Develop** impedance and admittances bus matrices.	III	Apply
CO4	**Use** Gauss Seidal, Newton Raphson and Fast decoupled method for load flow studies.	III	Apply

CO-PO Mapping:

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

Assessments:

Teachers' assessment-

In Semester Evaluation (ISE), and End Semester Examination (ESE) having 50% weightage each

Assessment	Marks
ISE	25
ESE(POE)	50

ISE is based on at least two of the assessment tools like performance of student in laboratory, experimental write-up, presentation, oral, and test (surprise/declared/quiz). ESE Assessment is based on performance in a practical examination and oral test thereafter at the end of the semester.

Course Content	Hours
Experiment No.1: Write a MATLAB programme to transform unsymmetrical components into symmetrical components and vice-versa.	2 Hrs
Experiment No.2: To Determine Fault Currents and Voltages in a power system with Star-Delta Transformers at a Specified Location for LG and LL by simulation.	2 Hrs
Experiment No.3: To Determine Fault Currents and Voltages in a power system with Star-Delta Transformers at a Specified Location for LLG and LLLG by simulation.	2 Hrs
Experiment No.4: Y Bus Formation for Power Systems with and without Mutual Coupling by Singular Transformation and Inspection Method.	2 Hrs
Experiment No.5: Formation of Z Bus (without mutual coupling) using Z-Bus Building Algorithm.	2 Hrs
Experiment No.6: Load Flow Analysis using Gauss Siedel Method for Both PQ and PV Buses.	2 Hrs
Experiment No.7: Load Flow Analysis using NR for Both PQ and PV Buses.	2 Hrs
Experiment No.8: Load Flow Analysis using Fast Decoupled Method for Both PQ and PV Buses.	2 Hrs
Experiment No.9: To determine Fault Currents and Voltages in a power system for a symmetrical three phase fault by simulation.	2 Hrs
Experiment No.10: Power angle characteristics of Salient pole rotor synchronous machines.	2 Hrs

Textbooks:

Sr. No.	Title	Edition	Author/s	Publisher	Year
1	Modern Power system Analysis – by I.J.Nagrath & D.P.Kothari: Tata McGraw-Hill Publishing company, 2nd edition.	4^{th}	I.J.Nagrath & D.P.Kothari	Tata McGraw-Hill Publishing company	2011
2	Power system Analysis Operation and control, Abhijit Chakrabarthi , Sunita Haldar, 3ed , PHI,2010.	2nd	Abhijit Chakrabarthi , Sunita Haldar,	PHI,2010	2010

References:

SN	Title	Edition	Author/s	Publisher	Year
1	Elements of Power System	4th	William D. StevensonJr	McGraw Hill.	1982
2	Power System Analysis and Design	4th	J.Duncan Glover et al	Cengage	2008

3	Power System Analysis	1st	Hadi Sadat	McGraw Hill.	2002

Experiment wise Measurable students Learning Outcomes:

1) The students will be able to do transformation of symmetrical components.
2) The students will be able to determine fault voltage and fault current for LG and LL type of fault.
3) The students will be able to fault voltage and fault current for LLG and LLLG type of fault.
4) The students will be able to form Y-bus by singular transformation and inspection method.
5) The students will be able to Z-bus using building algorithm.
6) The students will be able to do load flow analysis by Gauss-Seidal Method.
7) The students will be able to do load flow analysis by Newton Rapson Method.
8) The students will be able to do load flow analysis by Fast Decoupled Method.
9) The students will be able to do fault analysis for symmetrical faults.
10) The students will be able to obtain Power angle characteristics of Salient pole rotor synchronous machines.

Title of the Course: IOT Electrical Engineering Lab Course Code: UELC0633	L	T	P	Credit
	-	-	02	01

Course Pre-Requisite: Basics of IoT, Microcontrollers, Embedded Systems

Course Description: This course discusses the basics of IoT and enables the student to get acquainted with the required software and hardware necessary for implementing IoT solutions in real-world scenarios.

Course Objectives:

1. This course is designed to impart knowledge on the infrastructure, sensor technologies and networking technologies of IoT.
2. This course is designed such that the student can analyze and develop IoT solutions.
3. To understand the working of basic microcontrollers such as Arduino Uno and the programming associated with it.
4. To seamlessly integrate microcontrollers with smart devices for different applications.
5. To apply the concept of IoT in real world scenarios.

Course Outcomes:

COs	After the completion of the course the student will be able to	Blooms level	Descriptor
CO1	**Utilize** concepts of IoT to understand the working and implementation of IoT.	III	Applying
CO2	**Apply** programming techniques to Arduino Uno and sensors as part of IoT.	III	Applying
CO3	**Implement** interfacing of various sensors with Arduino.	III	Applying
CO4	**Apply** proper sensor technology for IoT application.	III	Applying
CO5	**Design** IoT applications useful in the field of electrical engineering.	VI	Creating

PO MAPPING

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

Assessments:
Teacher's assessment:

In Semester Evaluation (**ISE**), and End Semester Examination (**ESE**) having 50% weightage each.

Assessment	Marks
ISE	50
ESE	50

ISE is based on the performance of student in laboratory, experimental write-up, presentation, oral, and test (surprise/declared/quiz). The course teacher shall use at least two assessment tools as mentioned above for ISE.
ESE: Assessment is based on performance and oral examination

Course Contents: Perform the following 10 experiments.

Experiment 1:--- Introduction to Python Programming.

Experiment 2 -----Introduction to Arduino microcontroller and its programming

Experiment 3:--- Interfacing Arduino with smart phone for enabling home automation.

Experiment 4:--- Using condition and looping with LED

Experiment 5:--- Remote controlled LED using HC-05 Bluetooth

Experiment 6:--- Interfacing light dependent resistor and LED (Automatic Night Lamp)

Experiment 7:--- Remote data logging with Arduino using Socket Programming in Python

Experiment 8: --- Using the Arduino Uno to convert analog input signal to digital samples.

Experiment 9:--- Pulse Width Modulation using Arduino.

Experiment 10:--- Controlling SERVO motor using Mobile Application

References:

1. Designing the Internet of Things, Adrian McEwen and Hakim Cassimally, Wiley, First edition, 2013.
2. Getting Started with the Internet of Things, CunoPfister, O'reilly, 2011.
3. Internet of Things: A Hands-on Approach, ArshdeepBahga, and Vijay Madisetti, 2014.
4. Arduino Project Books, available online at https://www.uio.no/studier/emner/matnat/ifi/IN1060/v21/arduino/arduino-projects-book.pdf
5. Arduino Programming- The Ultimate Beginner's and Intermediate Guide to learn Arduino Programming Step by Step.

Experiment wise Measurable students Learning Outcomes:

Experiment 1:- The student will be able to understand the basics of python programming.

Experiment 2:- The student will be able to understand the basics of the hardware of Ardruino microcontroller and programming required for interfacing it.

Experiment 3:- The student will be able to interact with a Arduino controller using a smart phone and subsequently perform home automation.

Experiment 4:- The student will be able to sequentially turn LEDs on and off depending on certain conditions using Ardiuno programming.

Experiment 5:- The student will be able to control the working of a LED using HC-05 Bluetooth

Experiment 6:- The student will be able to interface a LDR with a Arduino Uno.

Experiment 7:- The student will be able to perform data logging from Arduino using Python and Excel.

Experiment 8:- . The student will be able to perform analog to digital conversion using Arduino Uno.

Experiment 9:-The student will be able to perform PWM using Arduino Uno.

Experiment 10:- The student will be able to control a servo motor using the HC05 Bluetooth module and Arduino Uno.

Title of the Course: Power Quality and Harmonics Lab Course Code: UELC0634	L	T	P	Credit
	-	-	2	1

Course Pre-Requisite: Basic Knowledge of electrical power system analysis.

Course Description: This course discusses the power quality issues due to harmonics and distortion by suing power analyzer and software for solving power quality issues.

Course Objectives:

1. To identify various power quality issues.
2. To understand relevant IEEE standards.
3. To illustrate various PQ monitoring techniques and instruments.
4. To learn and characterize various PQ problems.

Course Outcomes:

CO	After the completion of the course the student should be able to	Blooms level	Descriptor
CO1	**Evaluate** ability to identify various power quality issues.	III	Understanding
CO2	**Analyze** IEEE standards of various PQ monitoring techniques and instruments.	V	Analyse
CO3	**To** expand power quality problems .	III	Apply
CO4	**Use** of different power quality mitigation techniques.	III	Apply

CO-PO Mapping:

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

Assessments:

Teachers' assessment-

In Semester Evaluation (ISE), and End Semester Examination (ESE) having 50% weightage each

Assessment	Marks
ISE	25
ESE(OE)	50

ISE is based on at least two of the assessment tools like performance of student in laboratory, experimental write-up, presentation, oral, and test (surprise/declared/quiz). ESE Assessment is based on performance in a practical examination and oral test thereafter at the end of the semester.

Course Content	Hours
Experiment No.1: Study of power quality analyzer and measurement of voltage, current, power and power factor using it..	2 Hrs
Experiment No.2 Measurement of harmonic distortion of various Equipments such asUPS /AC/DC drive.	2 Hrs
Experiment No.3: Measurement of harmonic distortion of Desktop / computer and allied equipment	2 Hrs
Experiment No.4: Measurement of harmonic distortion of LED lamp, LED Screen and electronic ballast.	2 Hrs
Experiment No.5: Harmonic analysis of transformer for various conditions (no load, inrush, full load etc.).	2 Hrs
Experiment No.6: Harmonic compliance of institute as per IEEE 519-2014standard and sizing of active filter.	2 Hrs
Experiment No.7: Power quality audit of institute or department.	2 Hrs
Experiment No.8: Measurement of voltage sag magnitude and durationby using digital storage oscilloscope/ power quality analyzer.	2 Hrs
Experiment No.9: Analysis of performance of three phase inductionmotor operated with sinusoidal supply and under distorted supply conditions supplied by 3 phaseinverter	2 Hrs
Experiment No.10 Simulation studies of harmonic generation sources such as VFD, SVC, STATCOM and FACTS devices and harmonicmeasurement (THD) by using professional software like MATLAB.	2 Hrs

Textbooks:

Sr. No.	Title	Edition	Author/s	Publisher	Year
1	Power System Quality Assessment	4th	J. Arrillaga, M. R. Watson, S. Chan	John Wiley and Sons company	2011
2	Understanding Power Quality Problems, Voltage Sag and Interruptions	2nd	M. H. J. Bollen	", New York: IEEE Press, 2000, Series on Power Engineering	2000
3	Electrical Power System Quality	2nd Edition	R. C. Dugan, Mark F. McGranghan, Surya Santoso, H. Wayne Beaty	McGraw Hill Publication.	

References:

SN	Title	Edition	Author/s	Publisher	Year
1	Power System Harmonics: Computer Modeling & Analysis	2th	Enriques Acha, Manuel Madrigal	John Wiley and Sons Ltd.	
2	Power Quality in Power Systems and Electrical Machines	4th	Ewald F. Fuchs, Mohammad A. S. Masoum	Elsevier Publication	

3	IEEE recommended practices and requirements for harmonics control in electrical power system.	1st	IEEE Std. 519-1992	IEEE	1992

Experiment wise Measurable students Learning Outcomes:

1) Characterize power quality events.

2) Reproduce causes of voltage sag and estimate magnitude of voltage sag.

3) Carry out harmonic analysis and calculate total harmonic distortion.

4) Calculate parameters for passive harmonic filters.