BE Electrical and Computer Engineering

SEMESTER-I

Sr. No.	Course No.	Course Title	Type of Course	L	T	P	Credits
1	UPH004	Applied Physics	CF	3	1	2	4.5
2	UMA010	Mathematics –I	CF	3	1	0	3.5
3	UTA003	Computer Programming	CF	3	0	2	4.0
4	UEC001	Electronics Engineering	CF	3	1	2	4.5
5	UTA015	Engineering Drawing	CF	2	4	0	4.0
6	UHU003	Professional Communication	CF	2	0	2	3.0
				16	**7**	**8**	**23.5**

SEMESTER-II

Sr. No.	Course No.	Course Title	Type of Course	L	T	P	Credits
1	UCB008	Applied Chemistry	CF	3	1	2	4.5
2	UEE001	Electrical Engineering	CF	3	1	2	4.5
3	UEN002	Energy and Environment	CF	3	0	0	3.0
4	UMA004	Mathematics-II	CF	3	1	0	3.5
5	UES009	Mechanics	CF	2	1	2*	2.5
6	UTA018	Object Oriented Programming	CF	3	0	2	4.0
7	UTA016	Engineering Design Project-I (2 self-effort hours)	PR	1	0	2	3.0
				18	**4**	**10**	**25.0**

*** Each student will attend one Lab Session of 2 hrs in a semester for a bridge project in this course. (Mechanics)**

First Year Credit : 48.5

SEMESTER-III

Sr. No.	Course No.	Course Title	Type of Course	L	T	P	Credits
1	UCS405	Discrete Mathematical Structures	CF	3	1	0	3.5
2	UCS520	Computer Networks	CP	3	0	2	4.0
3	UCS301	Data Structures	CP	3	0	2	4.0
4	UEE409	Network Theory	CP	3	1	2	4.5
5	UEE505	Analog and Digital Systems	CP	3	1	2	4.5
5	UHU005	Humanities for Engineers	CF	2	0	2	3.0
6	UTA024	Engineering Design Project-II	PR	1	0	4	3.0
				18	**3**	**14**	**26.5**

SEMESTER-IV

Sr. No.	Course No.	Course Title	Type of Course	L	T	P	Credits
1	UCS303	Operating Systems	CP	3	0	2	4.0

2	UCS310	Data Base Management Systems	CP	3	0	2	4.0
3	ULC401	Computer System Design	CP	3	0	2	4.0
4	ULC402	Fundamentals of Signal Processing	CP	3	0	2	4.0
5	UEE413	Electric Machinery parappara	CP	3	1	2	4.5
6	UEE414	Principles of Power System Engineering	CP	3	1	2	4.5
				18	**2**	**12**	**25.0**

After Second year Credits=48.5+51.5=100

SEMESTER-V

Sr. No.	Course No.	Course Title	Type of Course	L	T	P	Credits
1	UMA028	Mathematics for Data Science	CF	3	0	2	4.0
2	UEE511	Embedded System Design and IoT	CP	3	0	2	4.0
3	UCS541	Foundations of Artificial Intelligence	CF	3	0	2	4.0
4	UEE512	Power Converters and Drives	CP	3	1	2	4.5
5	UEE508	Linear Control Systems	CP	3	1	2	4.5
6	UTA025	Innovation and Entrepreneurship (2 self-effort hours)	CF	1	0	2*	3.0
				16	**2**	**12**	**24.0**

Course Scheme is passed by Senate , TIET upto 5th semester.

SEMESTER-VI

Sr. No.	Course No.	Course Title	Type of Course	L	T	P	Credits
1	ULC601	Machine Learning Techniques	CP	3	0	2	4.0
2	UCS415	Design and Analysis of Algorithms	CP	3	0	2	4.0
3	UCS503	Software Engineering	CP	3	0	2	4.0
4	ULC602	Digital Measurement and Protection	CP	3	0	2	4.0
5	ULC603	Electric Vehicle and Real Time Systems	CP	3	0	2	4.0
6		Elective -1	PE	3/2	0	0/2	3.0
7	ULC691	Capstone Project (Starts)	PR	1*	0	2	--
				19/18	**0**	**12/14**	**23.0**

After third Year Credits= 100+47=147.0

SEMESTER-VII

Sr. No.	Course No.	Course Title	Type of Course	L	T	P	Credits
1	UCS701	Theory of Computation	CP	3	1	0	3.5
2	ULC701	Smart Electric Grid and Energy Management	CP	3	0	0	3.0
3		Elective -2	PE	2/3	0	2/0	3.0
4		Elective -3	PE	2/3	0	2/0	3.0
5		Generic Elective	GE	2	0	0	2.0
6	ULC691	Capstone Project	PR	0	0	2	8.0
				12/14	**1**	**6/2**	**22.5**

SEMESTER-VIII

Sr. No.	Course No.	Course Title	Type of Course	L	T	P	Credits	Remarks
1	ULC891	Project Semester	PR	--	--	--	15.0	--
OR Alternate Project Semester								
1	ULC892	Design Project	PR	--	--	--	8.0	PR
2	UCS813	SOCIAL NETWORK ANALYSIS	CP	2	0	2	3.0	
3	UCS806	ETHICAL HACKING	CP	3	0	2	4.0	
OR								
1	ULC893	Start-up Semester	PR				15.0	PR
							15.0	

After fourth year Credits= 147+37.5= 184.5

List of Professional Electives

Elective -1					
1	ULC641	Autonomous Mobility	3	0	0
2	UCS531	Cloud Computing	2	0	2
3	UCS653	Data Mining and Visualization	2	0	2
4	ULC643	Forecasting methods and applications	2	0	2
5	ULC664	Cyber and Network Security	2	0	2
6	UCS753	Deep Learning	2	0	2
7	UCS532	Computer Vision	2	0	2
Elective -2					
1	UCS635	GPU Computing	2	0	2
2	UMC622	Matrix Computation	2	0	2
3	ULC662	Charging Infrastructure	3	0	0
4	ULC663	Cyber Physical Systems	3	0	0
5	UEE525	Data Analytics Methods	2	0	2
6	ULC742	Digital Control Systems	3	0	0
7	UCS636	3D Modelling and Animation	2	0	2
8	ULC702	Industrial Communication Protocols and SCADA	3	0	0
Elective -3					
1	ULC741	Advanced Metering Infrastructure	3	0	0
2	ULC743	Electric Grid Security	2	0	2
3	ULC744	FACTS and Custom Power	3	0	0
4	ULC745	Modern Propulsion system and Robotics	2	0	2
5	UMA038	Optimisation and Heuristics	2	0	2
6	UCS751	Simulation and Modelling	2	0	2
7	UCS646	Game Design & Development	2	0	2
8	UCS754	Block Chain Technology and Applications	2	0	2

S.No.	Course No.	Course Name	L	T	P	Cr
1	UTD002	Employability Development Skills	2	0	0	2.0
2	UHU016	Introductory Course In French	2	0	0	2.0
3	UHU017	Introduction To Cognitive Science	2	0	0	2.0
4	UHU018	Introduction To Corporate Finance	2	0	0	2.0
5	UCS002	Introduction To Cyber Security	2	0	0	2.0
6	UPH064	Nanoscience And Nanomaterials	2	0	0	2.0
7	UEN006	Technologies For Sustainable Development	2	0	0	2.0
8	UMA069	Graph Theory And Applications	2	0	0	2.0
9	UBT510	Biology For Engineers	2	0	0	2.0

Total Credits : 184.5

The curriculum of BE(Electrical and Computer Engineering) is designed to offer mandatory and electives courses with a focus to acquire knowledge in specialised area.

Students will have choice of electives in the following groups:

1: Mathematics and Computing
2: High end computing
3: Information and Grid security
4: Computer Animation and Gaming
5: Electric Vehicle

Group 1: Mathematics and Computing 0. Maths for Data Science (PC) 1. Machine Learning Techniques (PC) 2. Data Mining (PE1) 3. Forecasting Methods and Applications (PE1) 4. Deep Learning (PE2) 5. Matrix Computation (PE2) 6. Optimisation and Heuristics (PE3)	**Group 2: High End Computing** 1. Design and Analysis of Algorithms (PC) 2. Cloud Computing (PE1) 3. GPU computing (PE2) 4. Deep Learning (PE2) 5. Simulation and Modelling (PE3)
Group 3: Information and grid security 1. Smart electric Grid and Energy management (PC) 2. Industrial Communication Protocols and SCADA (PE2) 3. Data mining (PE1) 4. Cyber and Network security (PE1) 5. Cyber Physical systems(PE2) 6. Electric Grid Security (PE3) 7. Block Chain Technology and Applications (PE3)	**Group 4: Computer Animation and Gaming** 1. Computer Vision (PE1) 2. 3D Modelling and Animation(PE2) 3. Game Design & Development(PE3)
Group 5: Electric Vehicle 1. Embedded Systems and IoT (PC) 2. Electric Vehicle and Real Time Systems (PC) 3. Autonomous Mobility (PE1) 4. Charging Infrastructure (PE2) 5. Digital Control system (PE2) 6. Advanced Metering System (PE3) 7. Modern Propulsion Systems and Robotics (PE3)	

SEMESTER VI

ULC601: MACHINE LEARNING TECHNIQUES				
	L	T	P	Cr
	3	0	2	4.0

Course Objectives: o understand the need, latest trends and design appropriate machine learning algorithms for problem solving

Introduction Definition of learning systems, machine learning, training data, concept representation, function approximation for learning system; Objective functions for classification, regression, and ranking.

Concept of Optimization: Convex function, gradients and sub-gradients, Unconstrained smooth convex minimization, gradient descent, Constrained optimization, Stochastic gradient descent

Regression and Supervised learning Linear regression and LMS algorithm, Perceptron and logistic regression, Nonlinear function estimation, Overfitting, Regularization

Support Vector Machines Maximum margin linear separators, solution approach to finding maximum margin separators, Radial basis function network, kernels and Mercer's theorem, Kernels for learning non-linear functions, support vector regression.

Decision Tree Learning: Representing concepts as decision trees, Recursive induction, splitting attributes, simple trees and computational complexity, Overfitting, noisy data, and pruning.

Bayesian Learning: Probability and Bayes rule, Naive Bayes learning algorithm, Parameter smoothing, Generative vs. discriminative training, Bayes nets and Markov nets for representing dependencies.

Clustering: Learning from unclassified data. Clustering. k-means partitioned clustering, Fuzzy C-means, Expectation maximization (EM) for soft clustering, Gaussian Mixture Model

Data Pre-processing: Methods: Data Cleaning, Data Integration, Data Transformation, Data Reduction; Feature Scaling (Normalization and Standardization), Splitting dataset into Training and Testing set. Principle Component Analysis (PCA), Linear Discriminant Analysis (LDA), Correlation based feature selection.

Applications to Power System: Some of the Power System applications but not restricted to energy pricing estimation, energy meter analytics, renewable generation forecasting, load profile and consumer classification, Controller design for ALFC, Filter design, Economic load dispatch.

Laboratory Work

Laboratory work: The laboratory work includes supervised learning algorithms, linear regression, logistic regression, decision trees, k-nearest neighbour, Bayesian learning and the naïve Bayes algorithm, support vector machines and kernels and neural networks with an introduction to Deep Learning and basic clustering algorithms.

Course Learning Objectives (CLO)

Course Learning Outcomes (CLO):

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

1. Analyze the complexity of machine learning algorithms and their limitations
2. Realize learning algorithms as neural computing machine
3. Demonstrate the ability to evaluate and compare learning models and learning algorithms
4. Realize algorithms on power system problems

Text Books:

1. Mitchell T.M., Machine Learning, McGraw Hill (1997).
2. Alpaydin E., Introduction to Machine Learning, MIT Press (2010).

Reference Books

1. Bishop C., Pattern Recognition and Machine Learning, Springer-Verlag (2006).
2. Michie D., Spiegelhalter D. J., Taylor C. C., Machine Learning, Neural and Statistical Classification. Overseas Press (2009)

Evaluation Scheme:

Evaluation Elements	% Weightage
Mid Semester Test	25
End Semester Examination	45
Sessional (may include Tutorial, Assignment, Lab work, Quiz , Project as applicable)	30
Total	100

ULC602: DIGITAL MEASUREMENT AND PRTECTION

L	T	P	Cr.
3	0	2	4.0

Course Objectives: The objective of this course is to provide a comprehensive up-to-date presentation of the fundamentals of digital measurement and digital protection through state-of –art theories and methods in digital relaying,

Fundamentals of Digital Measurement : Concept of sampling and aliasing, mean and RMS value theorem, power evaluation theorem, Time-division multiplexing, Quantization, A/D converters, digital instruments and their performance characteristics.

Digital Time and Frequency Measurement : Measurement of a Time Interval. Small Time Interval, Periodic Time; Phase Measurement. Measurement of R-L-C parameters.

Measurement of Frequency, ratio and multiplication of frequencies, high and low frequencies, average frequency difference. power system frequency deviation; Time reciprocating circuit; fast low-frequency measurement of sinusoidal signals, peak frequency measurement.

Estimation of phasors: Fourier transform, discrete Fourier transform, Discrete Cosine Transform; Estimation of phasors using Walsh function and Least Error Square techniques; estimation of frequency in digital relays**.**

Digital Relays: Fundamentals of digital relays; Basic layout and elements of the digital relays; Sliding window concept of digital relays. Digital Directional/Non-directional Overcurrent and Earth fault relays; relay coordination in an interconnected power system network: Digital distance relays.

Digital Protection of Power System equipment: Digital Differential Protection of Generator and Transformers and Busbar**,** Protection of transmission lines with digital distance relays; Power swing detection and blocking technique.

Frequency relaying: Load shedding, rate of frequency decline and frequency relays; Hazards and risk of islanding; Loss of coordination among protective devices:

Advanced metering : Introduction to Smart meters, Advanced metering infrastructure and phasor measurement unit (PMU)

Laboratory Work: Measurement of ground resistivity and resistance of a ground electrode, obtain time-current characteristics of different types of electromagnetic and digital overcurrent, differential relay, directional and distance relays, generator, transformer and transmission line protections, relalisation of concept of grading of relays, relay co-ordination, and islanding, realisation of digital protection schemes using simulation software like MATLAB/DigSILENT.

Course Learning Outcomes (CLO):

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

1. Demonstrate various digital measurement modules, associated circuits and sampled measurements
2. Demonstrate protection strategies applied for power system protection.
3. Design the basic earthing requirement for residential and other purposes.
4. Realize the various dynamic characteristics of digital relays for protection of transmission lines, transformers.
5. Identify the new developments in protective relaying and applications

Text Books:

1. Anderson, P.M., Power System Protection, IEEE Press, New York, 1999.
2. John A.T., Salman S.K., Digital protection for Power Systems, IEE Power Series: 15, 1995
3. Bhavesh Bhalja, R. P. Maheshwari, N. G. Chothani, Protection and Switchgear, Oxford University Press, 2nd edition, New Delhi, India, 2018.

Reference Books:

1. Blackburn, J.L., Applied Protective Relaying, Westinghouse Electric Corporation, New York, 1982.
2. Oza, B. A., Nair N. C., Mehta R.P., et al., Power System Protection & Switchgear, Tata McGraw Hill, New Delhi, 2010.
3. Bhavesh Bhalja and Vijay H. Makwana, ""Transmission Line Protection Using Digital Technology,"" Springer Science+Business Media Singapore Pte. Ltd; Singapore, January 2016
4. Phadke, A.G. and Thorp J.S., Computer Relaying for Power Systems, Research Study Press Ltd, John Wiley & Sons, Taunton, UK, 1988.

ULC603: ELECTRIC VEHICLE AND REAL TIME SYSTEMS

L	T	P	Cr.
3	0	2	4.0

Course Objectives: To introduce the students about importance of Electric Vehicle: technical challenges, benefits, and perspectives in real time environment. To make familiar with hardware components including measurement and control in hardware in loop system**.**

Introduction to Electric Vehicle – History, Components of Electric Vehicle, Comparison with Internal combustion Engine: Technology, EV classification, Motor Torque Calculations - rolling resistance, e grade resistance, acceleration force, total Tractive Effort, Torque required on the Drive Wheel.

Electric Drive and controller-Types of Motors, Selection and sizing of Motor, RPM and Torque calculation of motor, Motor Controllers, Component sizing, Physical locations, Mechanical connection of motor, Electrical connection of motor.

Energy Storage Solutions (ESS) - Cell Types (Lead Acid/Li/NiMH), Battery charging and discharging calculation, Cell selection and sizing, Battery lay-outing design, Battery pack configuration, Battery pack construction, Battery selection criteria.

Battery Management System (BMS)/Energy Management System (EMS) - Need of BMS, active and passive cell balancing, state of charge and state of health estimation, Battery thermal management system.

Introduction to Real Time Simulation - Hardware-in-loop simulation systems, distributed control architecture, reliability enhancement by redundancy, Real time operating systems: Features, primary components, Structured design of real time systems.

Control architecture in Real Time simulation: Developing a mathematical model for Power system and control, Mathematical model of the real environment, Design of hardware device meant to be used in HIL, Design of desired control schemes for AC and DC electrical machine drives and other applications.

Laboratory Work:
Working and Control of BLDC Motor for Two Wheeler Electrical Vehicle, PMSM Motor for 2-Wheeler Electrical Vehicle, Design and analyse a Passive Battery Management System for small Li-ion Battery Study of Battery Packaging using Cylindrical/Prismatic Cells. Testing of Charger of Electric vehicles for EV Battery, Design and analysis of speed control controller fro EV. Analysis the Symmetrical Components of Power System Network Using OPAL-RT. Design and analyse a three Level PWM Generation in OPAL RT.

Course Learning Outcomes:

After the completion of the course the students will be able to:

1. Relate the importance of Electric Vehicle and its application
2. Describe the working of Motor and Controller used in EV
3. Demonstrate the battery construction and cell configuration
4. Explain the Hardware-in-loop simulation systems in Electrical and Computer Engineering.
5. Explain about the mathematical model for power system and control in a real environment.

Text Books

1. Electric Vehicle Technology, James Larminie
2. Electrical Vehicle Technology. The Future Towards Eco-Friendly Technology, Sunil R. Pawar
3. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Ehsani
4. N. Hatziargyriou “Microgrids: Architectures and Control", Wiley-IEEE Press, January (2014).
5. HIL System catalogues; Opal-RT, RTDS and Typhoon

SEMESTER VII

ULC701: Smart Electric Grid and Energy Management

L	T	P	Cr.
3	0	0	3.0

Course Objectives: To get acquainted with the concepts of smart grid components., energy management system, distribution management system, techniques of communication, computer networking and cyber security for smart metering systems

Introduction to Smart Grid: Basics of power systems, definition of smart grid, need for smart grid, functions of smart grid, opportunities & barriers of smart grid, difference between conventional & smart grid, regulatory challenges, present development & International policies in smart grid.

Architecture of Smart Grid: Functional elements of Smart grid designs, transmission automation, distribution automation, renewable integration. Distribution energy sources, microgrids, storage technologies, electric vehicles and plug-in hybrids, environmental impact and economic issues.
Smart grid architecture, standards-policies, network architectures, IP-based systems, power line communications, SCADA system

Advanced Metering: Introduction to Smart meters, Advanced metering infrastructure and phasor measurement unit (PMU)

Tools and Techniques for Smart Grid: static and dynamic optimization techniques for power applications such as economic load dispatch, Conventional and evolutionary algorithms in power system

Communication Technologies in Smart Grid: Introduction to communication technology, architectures, standards, PLC, Zigbee, GSM, BPL, Local Area Network (LAN) – House Area Network (HAN) – Wide Area Network (WAN) – Broadband over Power line (BPL) – IP based Protocols – Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.

Energy Management in Smart Grid: General principles, Planning and program, concept and scope of demand side management (DSM). DSM Strategy, Planning, Implementation and its application, Energy Management System (EMS) , smart substations , substation automation, feeder Automation, smart switchgear, remote terminal unit, Intelligent

electronic devices , protocols, phasor measurement unit , wide area monitoring, protection and control, smart integration of energy resources.

Course Learning Outcomes:

Upon completion of this course, the students will be able to:

- Explain the concept and planning of smart grids
- Apply the various techniques of communication, computer networking and cyber security for smart metering systems.
- Analyze smart grids and distributed energy resources (DER) with evolutionary algorithms.
- Describe the components and functions of energy and distributed management system.
- Analyze the application of smart grid technology in power system through case studies.

Text Books

- Ali Keyhani, Mohammad N. Marwali, Min Dai, Integration of Green and Renewable Energy in Electric Power Systems, Wiley, (2009)
- Clark W. Gellings, The Smart Grid: Enabling Energy Efficiency and Demand Response, CRC Press, (2009)
- Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianz hong Wu, Akihiko Yokoyama, Smart Grid: Technology and Applications, Wiley, (2012)
- G. Masters, Renewable and Efficient Electric Power System, Wiley–IEEE Press, 2nd Edition, (2013).
- Stuart Borlase, Smart Grids (Power Engineering), CRC Press, (2012)

Reference Books

- Andres Carvallo, John Cooper, The Advanced Smart Grid: Edge Power Driving Sustainability, Artech House Publishers , (2011).
- James Northcote, Green, Robert G. Wilson Control and Automation of Electric Power Distribution Systems (Power Engineering), CRC Press.(2017)
- James Momoh, Smart Grid: Fundamentals of Design and Analysis, Wiley, (2012)

Evaluation Scheme

Evaluation Elements	% Weightage
Mid Semester Test	25
End Semester Examination	45
Sessional (may include Tutorial, Assignment, Lab work, Quiz , Project as applicable)	30
Total	100

ULC691: CAPSTONE PROJECT

		L	T	P	Cr
	ULC691: Semester VI (starts)	1	0	2	--
	ULC691: Semester VII (Completion)	0	0	2	8.0

Course Objective: To facilitate the students learn and apply an engineering design process in electrical and computer engineering, including project resource management. As a part of a team, the students will make a project, that emphasizes, hands-on experience, and integrates analytical and design skills. The idea is to provide an opportunity to the students to apply what they have learned throughout the course of graduate program by undertaking a specific problem.

Course Description: Capstone Project is increasingly interdisciplinary, and requires students to function on multidisciplinary teams. It is the process of devising a system, component or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs. It typically includes both analysis and synthesis performed in an iterative cycle. Thus, students should experience some iterative design in the curriculum. As part of their design experience, students have an opportunity to define a problem, determine the problem scope and to list design objectives. The project must also demonstrate that students have adequate exposure to design, as defined, in engineering contexts. Engineering standards and realistic constraints are critical in engineering design. The program must clearly demonstrate where standards and constraints are taught and how they are integrated into the design component of the project. Each group will have 4-5students. Each group should select their team leader and maintain daily diary. Each Group will work under mentorship of a Faculty supervisor. Each group must meet the assigned supervisor (2hrs slot/week) till the end of the semester (record of attendance will be maintained), as per the time slot which will be provided to them by the respective supervisor. This is mandatory requirement for the fulfilment of the attendance as well as the successful completion of the project. The faculty supervisor of the project will continuously assess the progress of the works of the assigned groups. Some part of the analysis and design of the system will be done in the first section of project in semester VI. The second section would comprise of completion of the project in semester VII in which each team will have to submit a detailed report of the project along with a poster.

Course Learning Objectives (CLO)

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

1. Identify design goals and analyse possible approaches to meet given specifications with

realistic engineering constraints.

2. Design an electrical engineering project implementing an integrated design approach applying knowledge accrued in various professional courses.
3. Perform simulations and incorporate appropriate adaptations using iterative synthesis.
4. Use modern engineering hardware and software tools.
5. Work amicably as a member of an engineering design team.
6. Improve technical documentation and presentation skills.

SEMESTER VIIi

ULC891: PROJECT SEMESTER

L	T	P	Cr.
-	-	-	15.0

Course Objectives: The project semester is aimed to facilitate the students learn and apply their acquired skill set for the system development in the domain of Electrical and Computer Engineering. Each individual student will undertake practical training in a professional engineering set up (a company, top educational institution, research institute etc.) hereafter referred to as host "organization" as deemed appropriate. As a part of a team, the students will make a project, which emphasizes hands-on experience, and integrates analytical, design, and development skills.

Course Description: The project semester gives the student the opportunity to translate engineering theory into practice in a professional engineering environment. The technical activity in the project semester should be related to both the student's engineering studies and to the host organization's activities and it should constitute a significant body of engineering work at the appropriate level. It should involve tasks and methods that are more appropriately completed in a professional engineering environment and should, where possible, make use of human and technology resources provided by the organization. The idea is to provide an opportunity to the students to apply what they have learned throughout the course of graduate program by undertaking a specific problem. It consolidates the student's prior learning and provides a context for later research studies. The student remains a full time registered student at Thapar Institute of Engineering and Technology during the project semester and this activity is therefore wholly distinct from any industrial interactions which may occur over vacation periods.

Assessment Details: Each student is assigned a faculty supervisor who is responsible for managing and assessment of the project semester. The faculty supervisor monitors the student's progress in a semester and interacts with the industry mentor during his/her visit to the host organization twice. The evaluation scheme in the projects semester includes a *Reflective Diary* which is updated throughout the project semester, a *Mid-Way Project Report*, a *Final Report* with Learning Agreement/Outcomes and an *End semester Presentation & Viva*. Each student will present his/her work to the panel of examiners which involves the faculty Supervisor and some other members from the department. The mentor from the host organization is asked to provide his assessment on the designated forms. The faculty supervisor is responsible for managing and performing the assessment of the project semester experience.

Course learning Outcomes (CLO):

Upon completion of project semester, the students will be able to:

1. develop skills necessary for time management, reporting and carrying out projects within an organization/industry.

2. acquire knowledge and experience of software and hardware practices in the area of project.
3. carry out design calculations and implementations in the area of project.
4. associate with the implementation of the project requiring individual and teamwork skills.
5. communicate their work effectively through technical report writing and presentation.
6. demonstrate the knowledge of professional responsibilities and respect for ethics

Evaluation Scheme:

Evaluation Elements	% Weightage
Goal Report	05
Mid-way Report	15
Final Report	20
Industry (Host) Mentor Evaluation jointly with Faculty mentor	20
Reflective Diary	10
End semester Examination (Presentation d Viva-Voce)	30
Total	100

ULC892: DESIGN PROJECT

L	T	P	Cr.
-	-	-	8.0

Course Objectives: The design project is introduced in Electrical and Computer Engineering undergraduate programme to include a practical training in the university itself for six months.

Course Description: The project offers the student the opportunity to demonstrate engineering theory into practice under the supervision of a faculty supervisor in electrical engineering department. The students are also offered with two courses. The technical activity in the project semester should be related to both the student's engineering studies and the faculty supervisor's guide lines to make working model in the area of application of electrical engineering. It involves tasks and methods that are more appropriately completed in an academic practical environment and should, where possible, make use of human and technology resources provided by the university. It consolidates the student's prior learning and provides a context for later research studies. The student remains a full-time registered student at Thapar University during the project semester and this activity is, therefore, wholly distinct from any industrial interactions which may occur over vacation periods.

Assessment Details: Each student is assigned a faculty supervisor who is responsible for managing and assessment of the alternate project semester. The faculty supervisor guides the students till the end of semester and monitors the student's progress throughout the same. This includes a Reflective Diary which is updated throughout the alternate project semester, an Interim Project Report, a Final Report with Learning Agreement/Outcomes and a Final Presentation & Viva which involves the faculty Supervisor and some other faculty members from the department.

Course Learning Objectives (CLOs):

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

1. Acquire knowledge and experience of software and hardware practices in the area
2. of project.
3. Carry out design calculations and implementations in the area of project.
4. Associate with the implementation of the project requiring individual and teamwork skills.
5. Communicate their work effectively through writing and presentation.
6. Demonstrate the professional responsibilities and respect for ethics in university ambiance.

Evaluation Scheme:

Evaluation Elements	% Weightage
First Presentation	20
Second Presentation	20

Final Presentation (may include Report, Presentation, Viva-Voce)	60
Total	100

ULC893: START-UP SEMESTER

L	T	P	Cr.
-	-	-	15.0

Course Objectives: The start-up semester is introduced in Electrical and Computer Engineering undergraduate programme to provide training and skills to encourage start-ups among students.

Course Description: Under this six month start-up project semester , the students will learn about the following:

- Fundamentals of 'Entrepreneurship & Innovation'
- Opportunity identification and evaluation, Customer validation
- Developing a Business Model Canvas
- Business Development Process related to the startup, relating theoretical framework with the business idea, Industry dynamics, opportunity canvas and regulatory aspects related to the business idea.
- Design thinking
- Technical development
- Financial management
- Entrepreneurial Marketing
- Interaction with existing Startups and pitching of projects,
- Presentation of Prototype/Working model/useful App or a working Software

Assessment Details: Each student is assigned a faculty supervisor and industry mentor. Faculty supervisor is responsible for managing and assessment of the Startup semester. The faculty supervisor monitors the student's progress in a semester and interacts with the industry mentor during his/her visit to the host organization twice.

The semester includes maintenance of a Reflective Diary, which is updated throughout the startup semester, an Interim Project Report, a Final Report with Learning Agreement/Outcomes and a Final Presentation & Viva, which involves the faculty Supervisor, and some other members from the department.

The mentor from the host organization is asked to provide the assessment on a designated form. The faculty supervisor is responsible for managing and performing the assessment of the startup semester experience.

Course Learning Objectives (CLOs)

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

1. Demonstrate an ability to develop a business plan.
2. Carry out design calculations/simulations and implementations in the area of
3. project.
4. Develop a prototype/working model/software application.
5. Comprehend the fundamentals of business pitching.
6. Demonstrate the knowledge of professional responsibilities and respect for ethics.

Evaluation Scheme

Evaluation Elements	% Weightage
First Evaluation	20
Second Evaluation	20
Final Evaluation	60
Total	100

ELECTIVE-I

ULC641: AUTONOMOUS MOBILITY				
	L	T	P	Cr
	3	0	0	3.0

Course Objectives: The goal of the course is to introduce students to the various technologies, the basics of automotive electronics, fundamentals of electronic control systems, and the evolution of these systems will be presented.

Understand Mobility And Its Evolution: Transportation Systems**,** Mobility and Ways of Life, Electric Mobility: Actual Changes Brought on by Electric Vehicles in Terms of Mobility Systems

Autonomous Cars: Introduction, Why Autonomous, Requirements, Software Architecture, Hardware Architecture.

Electric Mobility Technology: Introduction to electro-mobility, working of an e-car, the development of electro-mobility to the present day, Advantages of electro-mobility, Challenges facing electro-mobility, The e-car of the future**.**

Electric Vehicles & E Mobility: Electric Cars, Charging Infrastructure, Electric Grid, Battery Technology, Electric Vehicles Policies, Transport Modes Electrification, EV Business Models.

Drones Technology & Setup: Software & Simulated Drones, Main Components, Building Unmanned Vehicles, UAV Simulation, UAV Control.

Autonomous Robots: Introduction to the fundamentals of mobile robotics, examining the basic principles of locomotion, kinematics, sensing, perception, and cognition that are key to the development of the autonomous mobile robot.

Course Learning Outcomes:

Upon completion of this course, the student will be able to:

1. Explain the rationale and evolution of automotive electronics.

2. Describe the concept of fully autonomous vehicles.
3. Explain the application and utility of Mobile Robots used in various sectors and fields.

Text Books

Gerardus Blokdyk, Advanced Metering Infrastructure (AMI), Third edition, (2018)

Reference Books

1. Clark W. Gellings, The Smart Grid: Enabling Energy Efficiency and Demand Response, CRC Press, (2009).

2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Smart Grid: Technology and Applications, Wiley, (2012).

ULC643: FORECASTING MAETHODS AND APPLICATIONS

L	T	P	Cr.
3/2	0	0/2	3.0

Course Objective: This course aims to impart the depth-in-knowledge about the concepts of forecasting regression and economic methods, fundamentals of ARIMA time-series model and will learn the concept of advanced forecasting models.

Introduction: An overview of forecasting techniques, Explanatory versus time series forecasting, Qualitative forecasting, Basic steps in a forecasting task, Basic forecasting tools: Time series and cross-sectional data, Graphical summaries, Numerical summaries, Measuring forecast accuracies, Prediction intervals, Transformations, and adjustments

Smoothing and Decomposition Time Series Methods: Smoothing Methods: Averaging methods, Exponential smoothing methods, Other smoothing methods, Comparison of methods, General aspects of smoothing methods, Development of the mathematical basis of smoothing methods, Decomposition methods: Principles of decomposition, Moving average and its types, Classical decomposition method.

Regression and Economic Methods: Types of regression Methods, Least-squares estimation, Correlation coefficient, Cautions in using correlation, Simple regression, and the correlation coefficient, Residuals, outliers, and influential observations, Correlation and causation,

Multiple regression: Introduction to multiple linear regression, selecting independent variables and model specification, Multiple regression and the coefficient of determination, Assumptions behind multiple linear regression models

Box Jenkins (ARIMA) Time-Series Model: Fundamentals of Time-series Analysis, The Box Jenkins Methods: identification, Estimation of parameters, Diagnostic checking, Load forecasting with ARIMA Model

Advanced Forecasting Models: Dynamic regression models: Basic forms of the dynamic regression model, Forecasting, Koyck Model

Applications of Forecasting Techniques for load forecasting, solar energy forecasting

Course Learning Outcomes:

After completion of this course, student will be able to :

1. Explain the basics of forecasting techniques.
2. Comparison of smoothing and decomposition time-series methods.
3. Describe and comprehend various types of regression and economic methods.
4. Apply ARIMA time-series model in Load forecasting
5. **A**nalyze, model, and implement advanced models in load forecasting.

Text Books:

1. Markakis, S.G., Steven C. Wheelwright, Rob J Hyndman, Forecasting: Methods and Applications, Wiley Press, (1997).
2. Boylan John E., Syntetos Aris A., Intermittent Demand Forecasting: Context, Methods, and Applications, Wiley Press, (2022).

Evaluation Scheme:

Evaluation Elements	% Weightage
Mid Semester Test	30
End Semester Examination	45
Sessional (may include Tutorial, Assignment, Lab work, Quiz , Project as applicable)	25
Total	100

ULC664: CYBER AND NETWORK SECURITY

L	T	P	Cr.
2	0	2	3

Course Objectives: This course will enable students to know about security concerns in Email and Internet Protocol, understand cyber security concepts, list the problems that can arise in cyber security and discussion about the various cyber security frame work.

Transport Level Security: Web Security Considerations, Secure Sockets Layer, Transport Layer Security, HTTPS, Secure Shell (SSH).

E-mail Security: Pretty Good Privacy, S/MIME, Domain keys identified mail.

IP Security: IP Security Overview, IP Security Policy, Encapsulation Security Payload (ESP), Combining security Associations Internet Key Exchange. Cryptographic Suites.

Cyber network security concepts: Security Architecture, Anti-pattern: signature-based malware detection versus polymorphic threads, document driven certification and accreditation, policy driven security certifications. Refactored solution: reputational, behavioural and entropy-based malware detection. The problems: cyber anti-patterns concept, forces in cyber anti-patterns, cyber anti pattern templates, cyber security Anti-pattern CatLog.

Cyber network security frameworks: Enterprise security using Zachman framework Zachman framework for enterprise architecture, primitive models versus composite models, architectural problem-solving patterns, enterprise workshop, matrix mining, mini patterns for problem solving meetings.

Case study: Cyber security hands on managing administrations and root accounts, installing hardware, reimaging OS, installing system protection/ antimalware, configuring firewalls

Laboratory Work: Demonstrate use of Environment variables and privileged programs, Demonstrate Buffer Overflow and showcase EIP and other register status, insert malicious shell code into a program file and check its malicious or benign status, perform ARP poisoning, implement state ful firewall using IPTables.

Course Learning Outcomes (CLOs):

Upon completion of this course, the students will be able to:

1. Discuss the IP Security, Cyber network security concepts and cyber security problems.
2. Explain Enterprise Security using Zachman Framework.
3. Apply concept of cyber security framework to computer system administration.

Text Books:

1. William Stallings, “Cryptography and Network Security Principles and Practice”, Pearson Education Inc., 6th Edition, 2014, ISBN: 978-93-325- 1877-3.
2. Thomas J. Mowbray, “Cyber Security – Managing Systems, Conducting Testing, and Investigating Intrusions”, Wiley.

Reference Books:

1. Cryptography and Network Security, Behrouz A. Forouzan, TMH, 2007.
2. Cryptography and Network Security, Atul Kahate, TMH, 2003

Evaluation Scheme:

Evaluation Elements	% Weightage
Mid Semester Test	30
End Semester Examination	45
Sessional (may include Tutorial, Assignment, Lab work, Quiz , Project as applicable)	25
Total	100

ULC662: CHARGING INFRASTRUCTURE

L	T	P	Cr.
3	0	0	3

Course Objective: To familiarize the student with the essential components of the electric vehicle charging system, with an emphasis on power converters, communication system and connectors.

Energy Storage: Introduction to energy storage requirements in hybrid and electric vehicles, battery based energy storage and its analysis, fuel cell based energy storage and its analysis, super capacitor based energy storage and its analysis

Robust mechanical design and battery packaging: exposure to high impact forces, thermal runaway, structural safety and high cooling performance, robust and lightweight module frame, minimizing the deformation of batteries in case of swelling or explosion

EV Battery Charging Fundamentals: voltage levels and charging types, charging connectors, charging process, protection issues. Classification of EV chargers, AC charging and DC charging, Inboard and off board charger specification, Type of Mode of charger Mode -2, Mode-3 and Mode-4, differences between slow charger and fast charger, electric vehicle supply equipment (EVSE) and associated charge times calculation. Introduction to V2G and V2V modes, connected mobility, integration of EVs in smart grids, interdependence between EVs and photovoltaic systems.

Power Electronics in EV Battery Charging: Introduction of AC and DC Charging Station, Power Topologies in AC/DC conversion stage: single-phase active bridge power factor correction topology, three-phase active bridge power factor correction topology. Power Topologies in DC/DC conversion stage: boost converter, buck-boost converter (including bidirectional mode of operation), Dual Active Bridge (DAB) converter.

Selection and sizing of fast and slow charger (AC and DC): AC charging pile, DC charging pile, EVSE power module selection and technical specifications, selection of EVSE communication protocol (PLC / Ethernet / Modbus/ CAN Module), communication gateway, specification of open charge point protocol (OCCP 1.6/2.0), Bharat DC001 and AC001 charging specifications, communication interface between charger and CMS (central management system).

Selection and sizing of common types of connectors and applications: Selection of AC charger type-1, type -2 and type -3, communication between AC charger and EV, selection of DC charger connector GB/T, CHAdeMO , CCS-1 and CSS-2, communication methodology of DC fast chargers, IS/ IEC/ARAI/ standard of charging topology, communication and connectors (IEC 61851-1, IEC 61851-24,62196-2), sizing of connector cable.

Course Learning Outcomes:

Upon completion of this course, the students will be able to:

1. Clearly explain the charging process and fundamentals requirements expected from EVSE.
2. Demonstrate the role of power electronics equipment in EV charging.
3. Demonstrate the role of communication processes in EV charging.

4. Explain the selection procedure and sizing of charging connectors.

Text books:

1. Emadi, A. (Ed.), Miller, J., Ehsani, M., "Vehicular Electric Power Systems" Boca Raton, CRC Press, (2003)
2. Larminie, James, and John Lowry, "Electric Vehicle Technology Explained" John Wiley and Sons, (2012)

Reference books:

1. T R Crompton, "Battery Reference Book-3 rd Edition", Newnes- Reed Educational and Professional Publishing Ltd., 2000.
2. Amir Khajepour, Saber Fallah and Avesta Goodarzi, "Electric and Hybrid Vehicles Technologies, Modelling and Control: A Mechatronic Approach", John Wiley & Sons Ltd, 2014.
3. Sheldon S. Williamson, "Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles", Springer, 2013

Evaluation Scheme:

Evaluation Elements	% Weightage
Mid Semester Test	30
End Semester Examination	45
Sessional (may include Tutorial, Assignment, Lab work, Quiz , Project as applicable)	25
Total	100

ULC663: CYBER PHYSICAL SYSTEMS

L	T	P	Cr.
3	0	0	3

Course Objectives: This course introduces students to the design and analysis of cyber-physical systems (CPS) - the tight integration of computing, control, and communication.

Introduction: Definition of CPS, Applications (autonomous systems, frequency and voltage generation in electric grids), CPS as a multi-dimensional system, C PS challenges, embedded systems and cyber physical systems

Model based design of CPS: An introduction to model-based design, Modelling of Continuous Dynamics, Actor Model of Systems, Discrete Dynamics, hybrid modelling

Hybrid modelling: Hybrid modelling, Mealy finite state machine, Composition of Sate Machines, Concurrent Composition, Hierarchical State machines, Discrete event systems

CPS Hardware: Embedded system Hardware, Different sensors and actuators, Design issues with sensors and actuators (calibration, nonlinearity, sampling, noise)

CPS Design: Multitasking, OS, Micro-kernals, Thread Scheduling-basics, task models, Introduction to Edge AI, Study of electric grid as CPS, key smart grid challenges

Course Learning Outcomes:

Upon completion of this course, the students will be able to:

1. Explain the core principles behind CPSs.
2. Develop hybrid models and controls.
3. Identify safety specifications and critical properties of CPSs.
4. Describe abstraction and system architectures.
5. Relate the design by invariant.

Text Books

1. Platzer, A. Foundations of Cyber-Physical Systems. Lecture Notes, Computer Science Department, Carnegie Mellon University. (2016).
2. Lee E.A., Sanjit Arun kumar Seshia, Introduction to Embedded Systems: A Cyber-Physical Systems Approach, Lulu.com; 1st edition (2011)

Reference Books

1. Alur, Rajeev. Principles of Cyber-Physical Systems. MIT Press, (2015)
2. Peter Marwedel, Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems, Springer; 2nd Edition. edition (2010)
3. Wolf, Marilyn. High-Performance Embedded Computing: Applications in Cyber-Physical Systems and Mobile Computing. Elsevier, (2014)

4. Wolf, Marilyn. Computers as components: principles of embedded computing system design. Elsevier, (2017).

Evaluation Scheme:

Evaluation Elements	% Weightage
Mid Semester Test	30
End Semester Examination	45
Sessional (may include Tutorial, Assignment, Lab work, Quiz , Project as applicable)	25
Total	100

ULC665: DIGITAL CONTROL SYSTEMS

L	T	P	Cr.
3	0	0	3

Course Objective: To present the basic concepts on analysis and design of sampled data control system and to apply these concepts to typical physical processes.

Introduction to discrete time control system : Principle features of discrete time control system, Mathematical analysis and sampling process, quantizing and coding, Data acquisition, conversion and distribution system, Reconstruction of original signal from sampled signal

The Z-Transform: Fundamentals of Z-transform, Important properties and theorems of the Z-transform, Z-transform from the convolution integral, Inverse Z-transform, Direct Division, Partial Fraction, Inversion Integral, Z-transform method for solving difference equation

Analysis of discrete time control system : S-plane to Z-plane mapping and Vice-versa, Stability analysis of closed loop systems in the Z-plane, Discrete time equivalents of continuous time systems, Discrete time equivalents of analog controllers, Transient and steady state response analysis

Design and compensation of discrete time control system : Digital filters: structure, implementation, frequency response, applications, Control system controllers: structure, hardware/software features, responses to control signals, use of root locus and frequency domain concepts, Phase lead and phase lag compensator design for discrete time system, PID controller design and selection of parameters for discrete time system

Discrete time state equations : State space representation of discrete time systems, Discretization of the continuous time state space equation, Pulse transfer function matrix, Stability assessment from the discretized state space equations

Course Learning Outcomes: After completion of this course, student will be able to:

1. Analyze signals in both time domain and Z domain.
2. Analyze transient and steady state behaviors of linear discrete time control systems
3. Analyze the stability of digital control systems
4. Design digital controllers/compensators and assess their design through the constraint specifications, and decide whether their initial design is acceptable or can be improved.
5. Determine input and output sequence of state space represented discrete time systems.

Text Books:

1. Ogata K., Discrete Time Control Systems, 2nd Ed., Prentice Hall, Englewood Cliffs, New Jersey, (1995).
2. Charles L. Phillips, Digital Control System: Analysis and Design, Prentice Hall, Englewood Cliffs, New Jersey (1985)
3. Kuo, B.C., Digital Control Systems, The Oxford Series, 2nd Ed., (1995).

Evaluation Scheme:

Evaluation Elements	% Weightage
Mid Semester Test	30
End Semester Examination	45
Sessional (may include Tutorial, Assignment, Lab work, Quiz , Project as applicable)	25
Total	100

ULC702: INDUSTRIAL COMMUNICATION PROTOCOLS AND SCADA

L	T	P	Cr.
3	0	2	4.

Course Objectives: The objective of this course is to impart strong knowledge about industrial automation, communication technologies and SCADA in students, This course includes ndustrial communication protocols, Data Communication basics, network architecture and network protocols, typical SCADA system Architecture, Human machine interface, Properties of SCADA system, features. The course also includes SCADA protocols such as DNP3 protocol control net and applications of SCADA systems.

Industrial Communication Protocols: Introduction to Communication Protocols Data Communication basics, OSI reference model, Network Classification, Device Networks, Control Networks, Enterprise Networks. Introduction to Networks in process automation, Industry Networks, Network selection, Proprietary and open networks.

Network Architecture and Wireless Protocols: Network Architectures, Building blocks, Industry open protocols: RS-232, RS-422, RS-485, Ethernet, Modbus, Profibus, Fieldbus; Hardware: Fieldbus Design, Advantages and Limitations. Introduction to wireless Protocols Wi-Fi, Bluetooth, Overview of IEC 61850 Standard: Data Models, Communication Services.

Supervisory Control and Data Acquisition Systems: Introduction and block diagram of SCADA system, typical SCADA Architectures (First generation-Monolithic, Second generation- Distributed, Third generation–Networked Architecture), Properties of SCADA system , Advantages and limitations of SCADA system, DCS Vs SCADA, Human Machine Interface, SCADA security, Practical modern SCADA protocols: DNP3,60870.5 and related systems, API Std 1164 SCADA Security, Verification of security intelligence for a resilient SCADA system, SCADA system specification.

SCADA Protocols: Open systems interconnection (OSI) models, TCP/IP protocol, DNP3 protocol, IEC61850 layered architecture, Control and Information Protocol (CIP), Device Net, Control Net, Ether Net/IP, Flexible Function Block process (FFB), Process Field bus (Profibus). IEEE recommended practice for Master/Remote SCADA Communications.

Applications of SCADA system: Communication Protocols for Power System Communication requirements and its automation, SCADA systems in operation and control of interconnected power system.

Laboratory work: Experiments related to network communication protocols and SCADA for a specific plant can be performed.

Course Learning Outcomes (CLOs):

Upon completion of this course, the students will be able to:

1. Understand the various industrial communication protocols.
2. Describe the network architecture.
3. Identify the various architecture of SCADA system.
4. Illustrate the different SCADA protocols.
5. Analyze the challenges and issues in SCADA systems
6. Analyze about power distribution system and study of automation- SCADA

Text Books:

1. Eric Knapp, Joel Thomas Langill, "Industrial Network Security: Securing Critical Infrastructure Networks for Smart Grid, SCADA, and Other Industrial Control Systems", Elsevier, Second Ed., (2015)
2. Mini. S. Thomas and John D. McDonald, "Power System SCADA and Smart Grids", CRC Press, First Ed., (2015).
3. Ronald L. Krutz, "Securing SCADA System", Wiley Publications, (2005)
4. Stuart A Boyer, "SCADA supervisory control and data acquisition", ISA, 4th Revised edition, (2009)

Reference Books:

1. David J Teumim,, "Industrial Network Security", 2nd Edition-International Society of Automation ISA, (2010).
2. R. Radvanovsky, J. Brodsky , Handbook of SCADA/Control Systems Security, (2016).
3. B.G. Liptak, Process Software and Digital Network, CRC Press ISA- The Instrumentation, Systems, and Automation Society, 4th Ed., (2011)
4. User Manuals of Foundation Fieldbus, Profibus, Modbus, Ethernet, Devicenet, Controlnet, IEC 61850.
5. Peterson Davie, "Computer Networks—A System Approach", Maugann Kauffmann Publisher 6th Ed., (2021)
6. Fundamentals of Supervisory systems, IEEE tutorial, IEEE Press, (1991)

Evaluation Scheme:

Evaluation Elements	% Weightage
Mid Semester Test	25
End Semester Examination	45
Sessional (may include Tutorial, Assignment, Lab work, Quiz , Project as applicable)	30
Total	100

ELECTIVE III

ULC741: ADVANCED METERING INFRASTRUCTURE

L	T	P	Cr.
3	0	0	3.0

Course Objectives: To get acquainted with the concepts of smart grid components. To understand the concept of AMI with fundamental component. To apply the various techniques of communication, computer networking and cyber security for smart metering systems.

Fundamentals of Smart Grids: Existing power grid and its evolution with modernization, Concept of Smart Grid, Need of Smart Grid, Applications of Smart Grid to power systems, Different components of Smart Grid, Role of Intelligent Energy Network, Advanced Metering Infrastructure (AMI).

Advanced Metering Infrastructure (AMI): Detailed concept of Smart Grid and benefits, Basic concept and components of AMI, Challenges faced by AMI, Technologies and topologies of Automatic Meter Reading (AMR) and explain that smart meter is an impending entry point, Security Issues faced by AMI.

Fundamental component of AMI: Role of Smart Meter installed at subscribers' premises, focus on in-home security vulnerabilities of Smart Meter, and Energy Theft susceptibilities, and Smart Metering Programs based on enhanced cryptographies.

AMI protocols: Standards and initiatives, Demand side management and demand response programs, Demand pricing and Time of Use, Real Time Pricing, Peak Time Pricing.

Elements of communication, networking and interfacing: Architectures, standards, PLC, Zigbee, GSM, BPL, Local Area Network (LAN) - House Area Network (HAN) - Wide Area Network (WAN) - Broadband over Power line (BPL) - IP based Protocols - Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.

Fundamentals of Cyber Security: Types of Security Attacks and Threats, Model of Cyber Security and Security Protocols for Smart Grid. Highlight Information Assurance Fundamentals (such as Authentication, Authorization, Integrity, Confidentiality, and Non Repudiation, etc

Course Learning Outcomes:

Upon completion of this course, the students will be able to:

1. Explain the concept of smart grid electricity network.
2. Explain the concept and fundamental elements of AMI.
3. Comprehend the communication technologies involved and security aspects.

Text Books

1. Gerardus Blokdyk, Advanced Metering Infrastructure (AMI), 3rd Ed., (2018).

Reference Books

1. Gellings, C.W., The Smart Grid: Enabling Energy Efficiency and Demand Response, CRC Press, (2009).
2. Ekanayake J., Jenkins, N., Liyanage K., Smart Grid: Technology and Applications, Wiley, (2012).

Evaluation Scheme:

Evaluation Elements	% Weightage
Mid Semester Test	30
End Semester Examination	45
Sessional (may include Tutorial, Assignment, Lab work, Quiz , Project as applicable)	25
Total	100

ULC743: ELECTRIC GRID SECURITY

L	T	P	Cr.
2	0	2	3

Course Objectives: This course will introduce the students about the investigate key concepts behind electric grid security that includes cyberattack, vulnerability assessment and the Intrusion Detection System (IDS) development.

Introduction to grid security: Study of electric grids as a cyber-physical systems, key smart grid security challenges (physical and cyber), different cyber-attack events and their analysis (Ukrainian attack, STUXNET), current security initiatives

Types of attack: Cyber-attacks definition, their types**,** Strategic attack, template attack, location attack, modelling of attack (Time delay attack, denial of service attack)

Vulnerability assessment: Vulnerability assessment of different types of cyber-attack, case study in PMU, automatic generation control, economic load dispatch problems

Attack detection and prevention: State estimation methods, Observer-based different faulty data detection methods and AI-based schemes

Metrics for electricity sectors: Study of different metrics and protocols to evaluate and benchmark resilience, framework recommendations and technology evaluations.

Laboratory Work: Computer simulations related to modelling of the cyberattacks, analysis and detection methods of electric systems (automatic generation control/PMU systems economic load dispatch problem).

Course Learning Outcomes:

Upon completion of this course, the students will be able to:

1. Understand the meaning of cyber-attack in electric grids
2. Comprehend and model cyber attacks
3. Analyze the effects of cyber attack
4. Identify the types of attack
5. Learn how to make grid resiliency according to standards

Text Books

1. Borlase Stuart. Smart Grid: Infrastructure, Technology and Solutions, CRC Press, (2012).

Reference Books

1. Resilience Framework, Methods, and Metrics for the Electricity Sector (TR83), IEEE PES report.
2. Thomas, Mini S., McDonald. John D, Power System SCADA and Smart Grids, CRC Press, (2015)
3. Abur A. and Exposito A. G.**.** Power System State Estimation: Theory and Implementation, Marcel and Dekker Ink, (2004).

Evaluation Scheme:

Evaluation Elements	% Weightage
Mid Semester Test	30
End Semester Examination	45
Sessional (may include Tutorial, Assignment, Lab work, Quiz , Project as applicable)	25
Total	100

ULC744: FACTS AND CUSTOM POWER

L	T	P	Cr.
3	0	0	3.0

Course Objectives: This course aims to learn the concept of power flow control through various power electronic controllers including state of art FACTS controllers their operational aspects and their capabilities and their integration in power flow analysis so as to understand the basic concepts of power quality.

Basics of Transmission System And Facts Controllers: Reactive power flow control in Power Systems Control of dynamic power un-balances in Power System. Power flow control Constraints of maximum transmission line loading, Benefits of FACTS Transmission line compensation. Uncompensated line, Shunt compensation Series compensation , Phase angle control. Reactive compensation at transmission and distribution level.

Shunt Compensation: Passive shunt compensation: TCR-SC, TCR, TSR, TSC, TCR-SC, Description of Static versus passive VAR compensators, SVC and STATCOM - Operation and control of STATCOM, Comparison between shunt compensators.
Series Compensation: Basic characteristics, working principles, Impedance type series compensation, working of TCSC, TSSC, SSSC, Active Series Compensators: operating principles, SSSC, DVR operations.

Unified Power Flow Controller: SSR and its damping Unified Power Flow Controller: Circuit Arrangement, Operation and control of UPFC. Basic Principle of P and Q control, Applications
Interline Power Flow Controller: Principle of operation, Control and characteristics, Model of IPFC for power flow and optimum power flow studies.

Power Quality Issues And Application of FACTS: Voltage swells, sags, flicker, unbalance and mitigation of these problems by power line conditioners- IEEE standards on power quality, Application of FACTS devices for power-flow control and stability improvement. Example of power swing damping in a single-machine infinite bus system using a TCSC. Example of voltage regulation of transmission mid-point voltage using a STATCOM.

Course Learning Outcomes:
Upon completion of this course, the students will be able to:
1. Distinguish the performance of Transmission line with and without FACTS Devices
2. Compare the SVC and STATCOM
3. Understand the operation and control of various Static Series Compensators
4. Understand the operation and control of Unified Power Flow Controller

5. Distinguish various power quality issues and how are they mitigated by various FACTS
devices

Text Books

1. Hingorani, N. G. and Gyugyi, L., Understanding FACTS: Concepts and Technology of FACTS Systems, Wiley-IEEE Press, (1999).
2. Padiyar K. R., FACTS Controllers in Power Transmission and Distribution", New Age International (P) Ltd. , (2007).

Reference Books:

1. Song, Y.H. and Johns, A.T., Flexible AC Transmission Systems, IEEE Press (1999).
2. T. J. E. Miller, Reactive Power Control in Electric Systems, John Wiley and Sons, New York, 1983.
3. Zhang, X. P., Rehtanz, C. and Pal, B., Flexible AC Transmission Systems: Modelling and Control, Springer (2006).
4. G. T. Heydt, Electric Power Quality, Stars in a Circle Publications, 1991.
5. Thomas, Mini S., McDonald. John D, Power System SCADA and Smart Grids, CRC Press, (2015)
6. Abur A. and Exposito A. G.**.** Power System State Estimation: Theory and Implementation, Marcel and Dekker Ink, (2004).

Evaluation Scheme:

Evaluation Elements	% Weightage
Mid Semester Test	30
End Semester Examination	45
Sessional (may include Tutorial, Assignment, Lab work, Quiz , Project as applicable)	25
Total	100

ULC745: MODERN PROPULSION SYSTEM AND ROBOTICS				
	L	T	P	Cr
	2	0	2	3.0

Course Objective: This course aims to provide an in-depth knowledge about propulsion systems of electric vehicles and on robots for their control and design

Vehicle Propulsion model: Dynamic model of a vehicle, tractive force. Fundamental of propulsion, power transmission and brake system of an electric /hybrid vehicle: Sizing of the traction system in electric and hybrid vehicles, Power transmission in Electric and Hybrid Vehicles, Braking and Energy recovery in Electric and Hybrid Vehicle. Standard conduction cycles.

Introduction to Robotics: Types and components of a robot, Classification of robots, closed-loop and openloop control systems, Kinematics systems; Definition of mechanisms and manipulators.

Robot Kinematics and Dynamics: Direct kinematics problem, The inverse kinematics solution, DH parameters, Lagrange-Euler formation, Generalized D'Alembert equations of motion, Denavit Hartenberg convention and its applications.

Sensors and Vision System: Sensor: Contact and Proximity, Position, Velocity, Force, Tactile etc. Cameras and their calibration, Geometry of Image formation, Euclidean/Similarity/Affine/Projective transformations, Vision applications in robotics.

Robot Actuation Systems: Motor control for mobile robots, Servo control for robotic arms, Actuators: Electric, Hydraulic and Pneumatic; Transmission: Gears, Timing Belts and Bearings, Parameters for selection of actuators

Laboratory Work

Study components of a real robot and its DH parameters. Forward kinematics and validate using a software (Robo Analyser). Inverse kinematics of the real robot and validation using any software, Use of open source computer vision programming tool openCV. Positioning and orientation of robot arm, Integration of assorted sensors (IR, Potentiometer, strain gages etc.), micro-controllers and ROS (Robot Operating System)

Course Learning Objectives (CLO)

Upon the completion of the course the student shall be able to:

1. Perform kinematic and dynamic analyses with simulation.
2. Design control laws for a robot.
3. Integrate mechanical and electrical hardware for a real prototype of robotic device.
4. Select a robotic system for given application.

Text Books

1. J. M. Miller, Propulsion Systems for Hybrid Vehicles, 2nd Edition, (2010)
2. Saha, S.K., “Introduction to Robotics, 2nd Edition, McGraw-Hill Higher Education, New
Delhi, (2014).
3. Ghosal, A., “Robotics”, Oxford, New Delhi, (2006).
4. Niku Saeed B., “Introduction to Robotics: Analysis, Systems, Applications”, PHI, New Delhi.
5. Mittal R.K. and Nagrath I.J., “Robotics and Control”, Tata McGraw Hill.
6. Craig, J.J., Introduction to Robotics: Mechanics and Control, Pearson, New Delhi, (2009)

Reference Books

Reference Books

1. I. Husain, Electric and Hybrid Vehicles: Design Fundamentals, 2nd Edition, (2010)
2. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, Robot Modelling and Control, John Wiley and Sons Inc, (2005)
3. Steve Heath, Embedded System Design, 2nd Edition, Newnes, Burlington, (2003)
4. Merzouki R., Samantaray A.K., Phathak P.M. and Bouamama B. Ould,, Intelligent Mechatronic System: Modeling, Control and Diagnisis, Springer 2013.

UMA038: OPTIMIZATION AND HEURISTICS

L	T	P	Cr.
2	0	2	3

Course Objective: The main objective of the course is to formulate mathematical models and to understand solution methods for real life optimal decision problems. The emphasis will be on basic study of classical optimization techniques, non-linear programming, heuristic techniques and multi-objective optimization.

Introduction to Optimization Technique: Introduction, Engineering application of optimization, Statements of optimization problem, Classification of optimization problems.

Classical Optimization Techniques: Introduction, Solution approaches for single and multi-variable optimization problem with equality and inequality constraints, Linear programming (LP), Solution of LP by simplex method, Duality theory, and Dual simplex method.

Non-Linear Programming: Introduction, Interpolation methods: quadratic interpolation method, Direct root methods (Newton method, Quasi-Newton method), Direct search methods, Indirect search methods.

Heuristic Techniques: Introduction, Comparison with conventional techniques, evolutionary techniques, Genetic algorithm, Particle swarm optimization, Ant colony optimization.

Constraint Handling Techniques:
Constraint handling approaches, Challenges, issues and perspective, Constraint handling with metaheuristics

Multi-objective Optimization: Introduction, Principles of Multi-objective Optimization, Dominance and Pareto-Optimality, constrained multiobjective optimisation evolutionary algorithms

Applications of Engineering Optimisation in areas like power system operation planning, optimal power flow, pricing, automatic generation and control etc.

Laboratory Work: Implementation of classical and heuristic optimization techniques to solve single objective and multi-objective constrained optimization problems in the area of power system operation like economic load dispatch, optimal power flow, electricity pricing etc.

Course learning outcome (CLOs):
After the completion of this course, the students would be able to:

1. solve optimization problems using classical optimization techniques.
2. solve optimization problems using non-linear programming techniques.
3. apply heuristic techniques to solve complex optimization problems.
4. understand principles of multi-objective optimization.

Text Books:

1. Rao S.S., Engineering Optimization, Theory and Practice, John Wiley & Sons Inc. Fourth Edition, (2009).
2. Deb. K., Multi-Objective Optimization using Evolutionary Algorithms, Wiley, (2001)

Reference Books:

1. Nash S.G., Sofer A., Griv I., Linear And Nonlinear Optimization, Second Edition, SIAM, (2017).
2. Kothari D.P., Dhillon J.S., Power system Optimisation, PHI Learning, 2nd ed., (2011)
3. Bazaarra Mokhtar S., Jarvis John J. and Shirali Hanif D., Linear Programming and Network flows, John Wiley and Sons, (1990).
4. Swarup, K., Gupta, P. K., Mammohan, Operations Research, Sultan Chand & Sons, (2010).

Evaluation Scheme

Evaluation Elements	% Weightage
Mid Semester Test	25
End Semester Examination	45
Sessional (may include Tutorial, Assignment, Lab work, Quiz , Project as applicable)	30
Total	100