Master of Technology in Electric Vehicle Design

विद्युतीय अभियांत्रिकी विभाग

Department of Electrical Engineering

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Motivation and objectives:

India, along with several other rapidly growing economies, has recognized the imminent need for electrification of transport systems. The benefit derived from this transition will be two-fold: first, it will help the country to reduce the dependence on fossil fuel that is primarily imported and has significant budgetary implications; second, with a penetration of clean fuel and renewables in the electricity generation sector, this transition will be able to contribute towards mitigation of greenhouse emissions. To this end, the Government of India (GoI) has already put schemes, e.g., FAME, in action, and is actively looking for collaboration with the relevant industries and academia. While the industry is expected to focus on the production and distribution of electric vehicles (EVs), the responsibility of training the manpower for this cause is assigned to the academia.

The M.Tech in Electric Vehicle Design at NIT Jalandhar has been designed in alignment with the objectives of the initiative taken by the GoI and to cater to the growing demand of skilled personnel in the EV industry both the new EV entrepreneurs and the existing ones.

Objectives of the program:

- Equipping the students with both the conceptual and practical knowledge pertaining to the electric transport industry.
- Exposing the students to cutting-edge research on electric transportation through various courses, projects, systems design (winter/summer short project), and dissertation.
- Enhancing their employability in the EV industry by engaging them in solving problems that originated in the industry in their year-long dissertation.

Name of the Degree Program:
Master of Technology in **Electric Vehicle Design**

Abbreviation
Master of Technology is abbreviated as M.Tech.

Categories of Admission:
Candidates will be admitted to the M.Tech. Program of the Institute under one of the following categories:

i Regular full-time students with Half-teaching Research Assistantship (HTRA)
ii Regular full-time students without HTRA assistantship.
iii Full time self-finance without HTRA assistantship.

Duration:
The duration of this program is two years. Each year consists of two semesters, summer and winter terms. However, Half-teaching Research Assistantship (HTRA) duration will be governed as per Institute norms.

Credits to be earned:
The students have to earn minimum of 65 credits for the degree of Master of Technology in this specialization. For more details on credit distribution please refer to ordinance and regulations for M.Tech. of NIT Jalandhar.

Eligibility:
a Candidates who have qualified for the award of Bachelor's degree in Engineering / Technology with minimum first class or 60% aggregate marks (or Equivalent CGPA) in all the four years from a recognized University or Institute in Electrical Engineering (EE), Electrical & Electronics Engineering (EEE), Instrumentation and Control (IC) and who have qualified and have a valid score in Graduate Aptitude Test in Engineering (GATE) are eligible to apply for admission to this program.

b For all B.Tech from IITs graduated with a CGPA of 8.0 or above, the requirement of GATE qualification is waived off.

c A student sponsored by a recognized R&D organization, academic institution, government organization or industry with minimum first class or 60% aggregate marks (or Equivalent CGPA) in their Bachelor's degree in the aforementioned disciplines are eligible to apply for this program on a full-time basis. The Institute does not provide any assistantship to such students.

Number of Seats:
The number of seats shall be as approved by the BoS.

Assistantship (Fellowship/Scholarship):
The award of assistantship shall be in accordance with prevailing norms of the Institute.

Course Structure

Structure of Curriculum for M.Tech Programme in Electric Vehicle Design

Duration	Two years (4 semesters)
Number of Courses	Number of Courses 12 (Theory); 4 (Laboratories)
Dissertation work	2 semesters
Total Credits	80
Core Courses	(Theory) 8
Department Electives	(Theory) 4

Credit Distribution for M. Tech in Electric Vehicle Design					
Category	**Sem – I**	**Sem - II**	**Sem - III**	**Sem – IV**	**Total No. of Credits to be earned**
Core Courses	12	12	-	-	24
Electives	6	6	-	-	12
Lab Courses	4	4	-	-	08
Independent Study	-	-	03	-	03
Dissertation	-	-	15	18	33
Total	**22**	**22**	**18**	**18**	**80**

Proposed Course Structure and Syllabus for M. Tech in Electric Vehicle Design

SEMESTER- ONE				
S. No.	**Course Code**	**Title of the course**	**L-T-P**	**Credit**
1	EEEV-501	Fundamental of Electric Vehicles	3-0-0	3
2	EEEV-503	Power Electronics and Electric Drives	3-0-0	3
3	EEEV-505	Embedded Systems	3-0-0	3
4	EEEV-507	Modeling and Simulation of E-Vehicles	3-0-0	3
5	EEEV-XX	Elective-1	3-0-0	3
6	EEEV-XX	Elective-2	3-0-0	3
7	EEEV-523	Power Electronics and Electric Drives Laboratory	0-0-3	2
8	EEEV-525	Embedded System Laboratory	0-0-3	2
		Total	18-0-6	22

SEMESTER- Two				
S. No.	**Course Code**	**Title of the course**	**L-T-P**	**Credit**
1	EEEV-502	Digital Signal Processing	3-0-0	3
2	EEEV-504	Battery and Battery Management System	3-0-0	3
3	EEEV-506	Advanced Control System for Electric Vehicles	3-0-0	3
4	EEEV-508	Special Electrical machines and Control	3-0-0	3
5	EEEV-XX	Elective-3	3-0-0	3
6	EEEV-XX	Elective-4	3-0-0	3
7	EEEV-528	Electric Vehicle Laboratory	0-0-3	2
8	EEEV-522	Digital Signal Processing Laboratory	0-0-3	2
Total			18-0-6	22

SEMESTER- THREE				
S. No.	**Course Code**	**Title of the course**	**L-T-P**	**Credit**
1		Independent Study	--	3
2		M.Tech Dissertation		15
3		Industrial Training (Optional)		--
Total				18

SEMESTER- FOUR				
S. No.	**Course Code**	**Title of the course**	**L-T-P**	**Credit**
1		M.Tech Dissertation	--	18
2		Industrial Training (Optional)	--	--
Total			--	18

List of Discipline Electives:

- State Space Modeling and Control
- Hybrid Vehicle Technology
- Modelling Simulation and reliability
- Plug in Electric Vehicles
- Advanced Composite Materials for Automobiles
- Energy Storage Technologies
- Smart Grid
- Optimization Techniques
- Soft Computing and Intelligent Systems
- Nonlinear Analysis and Control of Power Electronic Converters
- Model Predictive Control

- Nonlinear Stability and Control
- Renewable Energy Systems
- Power Quality Problems and Mitigation Techniques in Microgrids
- Computer Aided Design of Power Electronic systems and Electrical Drives
- Design of Energy System
- Electric Vehicles: Economics, Policy and Social Embedding
- Mechatronics
- Power System Relaying
- Autonomous Vehicles
- Robotics and Autonomous Guided Vehicles
- Smart Sensers
- Introduction to Data Analytics
- Power System Flexibility
- Power Market Operation of Electric Vehicles

A few more electives will be added as DEs.

M.Tech 1st Semester

EEEV-501	Fundamental of Electric Vehicles						[3-0-0]
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓				✓		
CO2	✓	✓		✓	✓		
CO3	✓	✓	✓	✓		✓	
CO4	✓	✓	✓	✓		✓	✓

Course Outcome: On successful completion of this course the student will be able to:

1. **Know the overview of electric and hybrid vehicles.**
2. **Learn energy consumption concept of hybrid electric drive trains.**
3. **Learn different energy storage technologies used for hybrid electric vehicles.**
4. **Learn architecture and performance of electric and hybrid vehicle.**

Overview of electric vehicles in India, Review of conventional vehicle, Introduction to hybrid electric vehicles: Types of EVs, Hybrid electric drive-train.

Transmission gears, Manual Transmission (MT), Automatic Transmission (AT), Automated Manual Transmissions (AMT) and Continuously Variable Transmissions (CVT); Manual transmissions powertrain layout and manual transmission structure, Power flows and gear ratios, Manual transmission clutch and its structure. Drivetrain and differential.

Energy consumption concept of hybrid electric drive trains, Architecture of hybrid electric drive trains, Series hybrid electric drive trains, Parallel hybrid electric drive trains, Electric propulsion unit, Configuration and control of DC motor drives, Induction motor drives, Permanent magnet motor drives, Switched reluctance motor.

Introduction to energy storage requirements in hybrid and electric vehicles, Battery based energy storage and its analysis, Battery Charging and swapping, Fast charging, on-board charging, off grid charging. Fuel cell-based energy storage and its analysis, Hybridization of different energy storage devices, Comparison of different energy storage technologies for HEVs, Sizing the drive system, Design of hybrid electric vehicle and plug-in electric vehicle.

Series HEVs, Parallel HEVs, Series–Parallel HEVs, Complex HEVs, Operating modes, Degree of hybridization, Comparison of HEVs, Plug-in hybrid electric vehicles (PHEVs) Real life examples of HEVs, performance of ICE vehicles, HEVs and EVs. Future of EVs.

Text Book

1 Vehicle Powertrain Systems by Behrooz Mashadi and David Crolla, Wiley, 2012
2 Electric Vehicle Technology Explained by James Larminie and John Lowry, John Wiley, 2012
3 Electric and Hybrid Vehicles- Design Fundamentals by Iqbal Husain, CRC Press, 2021

EEEV-503	Power Electronics and Electric Drives	[3-0-0]

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓		✓				✓
CO2			✓	✓	✓	✓	
CO3		✓			✓	✓	
CO4				✓			

Course Outcome: On successful completion of this course the student will be able to:

1. **Analyze performance of uncontrolled and controlled switches and PWM schemes of Voltage Source Inverters.**
2. **speed control of electrical DC drives and its performance.**
3. **Evaluate the performance of AC Voltage Controller fed induction motor drive.**
4. **Learn energy conservation in electrical drives**

Power Electronic Devices: Gate Turn-off Thyristor (GTO), Power bipolar transistor, Power MOSFET, Insulated gate bipolar transistor (IGBT), Static induction thyristor (SIT), FET-BJT Combination Switch, MOS-controlled thyristor, Protection Circuit, Gate drive circuits.

AC-AC, DC-DC converters: Thyristor fed AC loads, the cycloconverter and Matrix converter. Buck, boost, and buck-boost configurations, Cuk converter for charging and discharging batteries.

Pulse-Width Modulated Inverters: Single-phase and three-phase square wave inverters operating principles of single phase and three phase PWM inverters, modulation techniques, SPWM, selective harmonic elimination PWM, space vector modulation techniques.

Multilevel Inverters: Types of multilevel inverters, Diode-clamped multilevel inverters, Flying capacitor multilevel inverter, Cascade multilevel inverters and features of multilevel inverters.

DC Motor Drives: DC motor and their performances, DC motor control, Chopper control of DC motors, Multi quadrant control of DC motor drive, Power losses and efficiency in DC Machines, Machines operating as motor or generator in forward or reverse modes, Design criteria of DC motor drives for EV.

Induction Motor Drives: Induction motor analysis and performances, Analysis of induction motor fed from non-sinusoidal voltage supply, Motor stating and breaking, Variable-speed operation of induction machines, Voltage source inverter control, Constant voltage/ hertz control, Field orientation control, Slip power recovery-Static Scherbius and Cramer drives. and DTC, Design Criteria of Induction Motor Drives for EVs

Energy Conservation in Electrical Drives: Losses in electrical drive system, Measures for energy conservation in electric drives, Use of efficient motor, Energy efficient operation of drives, Improvement of power factor and quality of supply.

Text Book

1 M.H. Rashid, Power Electronics, Circuits, Devices, and Applications, Pearson, 2017.
2 N. Mohan, T.M. Undeland & W.P. Robbins, Power Electronics: Converter, Applications & Design, John Wiley & Sons, New York, 2007.
3 G. K. Dubey: Fundamentals of Electrical Drives, 2nd Edition, Alpha Science International, 2001.
4 Electric Powertrain Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles By John G. Hayes, G. Abas Goodarzi, 2017

EEEV-505	Embedded Systems	[3-0-0]

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓		✓		✓	✓	✓
CO2				✓			
CO3		✓	✓		✓		
CO4		✓			✓		

Course Outcome: On successful completion of this course the student will be able to:

1. **Understand the architecture, hardware, programming and interfacing of the Intel 8051 microcontroller.**
2. **Develop microcontroller-based systems for real time applications.**
3. **Understand the basic concepts of embedded system design and its applications to various fields.**
4. **Understand various Communication and Interfacing processors.**

Embedded System: Introduction to Embedded system, History of embedded system, Components of embedded system, Classification of embedded system, Applications, Characteristics of embedded system, Constraints, Fundamentals of embedded system hardware, software and firmware, Processor in the System, Embedded processor selection. Introduction to RISC/CISC based machines.

Embedded Processors: Hardware characteristics & salient features of 16-bit – 64-bit processors, Internal architecture & programming model of 8086 16-bit processor; its algorithmic consideration for constructing machine codes and assemble language, hardware requirements and considerations, System connections and troubleshooting, device I/O types, hardware interfacing and industrial control, Interrupt applications, Strings, Procedures, Directives. Embedded processors in EVs.

Microcontrollers: Overview of 8,16,32-bit microcontrollers, 8051 based 8-bit microcontroller architecture, its I/O Ports, its timers, Interrupts, Serial communication, Programming, Introduction to PIC and ARM Processor, Operating System, Introduction to RTOS, Introduction to open source and miniature computing system, Importance of microcontroller in EVs.

Communication and Interfacing: Synchronous and asynchronous communications from serial devices - USART, Programmable Peripheral Interfaces, Programmable Interrupt Controller, Programmable Timer, Interfacing, DMA controller, Parallel Port Devices, Microcontroller connections to RS-232, its intra-inter process communication and synchronization of processes using on-chip timers/counters, interrupt sources, serial communication, Interfacing applications, Embedded processor based Real time applications. Application of embedded processor in EVs.

<u>Text Books</u>

1 Barry. Douglas V. Hall, “Microprocessor & Interfacing: Programming & Hardware” Tata McGraw Hill.
2 Muhammad Ali Mazidi, Janice Gillispie Mazidi and Rolin D. McKinlay,“The 8051 Micro controllers & Embedded Systems Using Assembly and C” 2nd Indian reprint, Pearson education.
3 Brey, “Intel Micropocessors, The 8056/8055, 80186/80188, 8028, /80386, 80486, Pentium & Pentium Pro, Pentium II, III, IV: Architecture, Programming and Interfacing” 8th edition, PHI, 2008.
4 Han-Way Huang and Leo Chartrand, “PIC Microcontroller: An Introduction to Software & Hardware Interfacing” Thomson Delmar Learning, 2004.
5 Steve Furber, “ARM System-on-Chip Architecture” 2nd Edition, Pearson Education Limited.
6 William Hohl, “ARM Assembly Language: Fundamentals and Techniques” CRC Press, 2009.
7 Tammy Noergaard, “Embedded Systems Architecture: A Comprehensive Guide for Engineers and Programmers (Embedded Technology)” Elsevier, Newnes.

EEV-507	Modeling and Simulation of E-Vehicles	[3-0-0]

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓		✓		✓	✓	✓
CO2				✓			
CO3		✓	✓		✓		
CO4		✓			✓		

Course Outcome: On successful completion of this course the student will be able to:

1. **Describe the internal characteristics of the electric vehicle battery.**
2. **Do the analysis of the electric vehicle battery.**
3. **Do the simulation based on internal parameters of electric vehicle.**

Electrical Vehicle Design and Modelling: Introduction, Vehicle modelling, Battery electrical model, Design method, Battery charging control.

Modelling and Analysis of Electric and Hybrid Electric Vehicles: Introduction, the Longitudinal dynamics equation of motion, Vehicle propulsion modelling and analysis: Internal combustion engine vehicles, Electric vehicles, Hybrid electric vehicles, Vehicle braking modelling and analysis.

Handling Analysis of Electric and Hybrid Electric Vehicles: Introduction, Simplified handling models, Single track linear handling model, Analytical handling analysis, Roll and pitch dynamics models, Comprehensive handling model of EVs and HEVs, Vehicle kinetics model, Tire model, Powertrain and Wheel dynamics model simulation study.

Energy/Power Allocation and Management: Introduction, Power/Energy management controllers, Rule-Based control strategies, Deterministic Rule-Based control strategies, Fuzzy-Rule-Based control strategies, Rule-Based control strategies for PHEVs, Fuzzy-Rule-Based control strategies, Optimization problem formulation, Global Energy/Power management optimization, Real-Time energy/power management optimization, Optimization techniques.

Modelling and Characteristics of EV/HEV Powertrains Components: ICE performance characteristics, Power and Torque generation, Mean effective pressure specific fuel consumption, Fuel conversion efficiency, Mechanical efficiency, Air–Fuel ratio, Compression ratio, Relationships between ICE performance characteristics, Battery performance characteristics, Battery capacity, Open circuit and terminal voltages , Charge/Discharge rate, State of charge/discharge, Depth of discharge, Battery power density and Specific power, battery efficiency.

Text Books

1 Amir Khajepour, Saber Fallah, Avesta Goodarzi "Electric and Hybrid Vehicles Technologies, Modelling and Control: A Mechatronic" Approach. April 2014, Wiley publications.
2 Seref Soylu, "Electric Vehicles – Modelling and Simulations" Sept. 2011, Published by InTech.

EEEV-523	Power Electronics and Electrical Drives Laboratory	[0-0-3]

Course Outcome: On successful completion of this course the student will be able to:

1. **Gain knowledge and expertise in Simulink to build control rectifier and Inverters.**
2. **Understand the operation of controlled DC motor drives.**
3. **Operation and control of Induction motor drives**.

At least 8 experiments are to be performed out of the following Suggested List of Experiments:

Suggested List of Experiments:

1. Evaluate performance parameters of three phase converter with RL load.
2. Compare the performance of unipolar PWM and bipolar PWM scheme in single phase VSI
3. Develop sine PWM scheme for three phase VSI.
4. Develop Space Vector PWM scheme for three phase VSI.
5. Analyze the operation of Buck and Boost converter under CCM and DCM.
6. Four quadrant operation of chopper with R load.
7. PWM control of Boost converter with R and RL loads.
8. Simulation of single-phase inverter with current controlled PWM technique.
9. Simulation of single phase fully controlled PWM rectifier with R & RL loads.
10. Micro controller based PWM pulse generation.
11. Determination of output voltage and frequency of 1-phase step down Cyclo converter with R & RL loads for different firing angles.
12. Output voltage characteristics of 3-phase IGBT based PWM Inverter on R & RL loads for different modulation indices.
13. Speed control of three phase converter-controlled dc motor drive.
14. Study and analyze the performance of four quadrant operation of chopper fed dc motor drive.
15. Determination of speed and output voltage of 3-phase AC voltage controller fed induction motor drive.

16 Starting and Running characteristics of capacitor start & capacitor run single phase induction Motor.

17 Output voltage characteristics of flying capacitors multi-level inverter fed induction motor drive.

18 Speed control of a three- phase slip ring Induction motor by Static Rotor Resistance Control.

19 Speed control of a three- phase induction motor drive using vector control method.

The list of experiments given above is only suggestive. The Instructor may add new experiments as per the requirement of the course.

EEEV-525	**Embedded System Laboratory**	**[0-0-3]**

Course Outcome: On successful completion of this course the student will be able to:

1 **The students will gain knowledge of architecture and programming of 16- and 64- bit processors and 16-bit microcontroller.**

2 **This course introduces RISC/ System-on-chip machines and RTOS and provide the students the ability to interface the processor/ microcontroller with peripheral devices.**

Programming exercises using embedded processors, Interfacing of LEDs, Switches, Relays, LCD, 7 Segment Display, ADC, DAC, Stepper Motor etc, ZigBee, RFID, GSM, Sensors.

The list of experiments given above is only suggestive. The Instructor may add new experiments as per the requirement of the course

M.Tech 2st Semester

EEEV-502	Digital Signal Processing	[3-0-0]

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓			✓			
CO2	✓	✓		✓		✓	✓
CO3	✓	✓	✓	✓	✓	✓	
CO4	✓		✓	✓	✓		✓

Course Outcome: On successful completion of this course the student will be able to:

1 **Discriminate discrete signals and systems from continuous ones and understand the process of discretization.**
2 **Analyze discrete time signals in frequency domain.**
3 **Design digital filters with the concept of z-transform.**
4 **Interpret key architectural features of Digital Signal Processor.**

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

Discrete Time System Analysis: Z-transform and its properties, inverse Z-transforms; difference equation – Solution by Z-transform, application to discrete systems - Stability analysis, frequency response – Convolution – Fourier transform. Discrete Fourier Transform & Computation: DFT properties, magnitude and phase representation - Computation of DFT using FFT algorithm – DIT & DIF - FFT using radix 2 – Butterfly structure.

Design of Digital Filters: FIR & IIR filter realization – Parallel & cascade forms. FIR design: Windowing Techniques – Need and choice of windows – Linear phase characteristics. IIR design: Pole-zero placement, Impulse-invariant, matched z-transform and bilinear transformation methods.

Digital Signal Processors: Introduction – Architecture – Features – Addressing Formats – Functional modes - Introduction to commercial processors. Application of digital signals processors in EVs.

Text Books

1 Proakis J G and Manolakis DG, "Digital signal processing," Pearson Education India
2 Ifeacher EC and Jerris BW, "Digital signal processing - A practical approach," Pearson Education Reference Books
3 Chen C-T, "Digital signal processing - Spectral computation and filter design,"

Oxford University Press
4 Ambardar A, “Digital signal processing - A modern introduction,” Cengage Learning India
5 Lyons RG, “Understanding Digital Signal Processing,” Pearson Education India

EEEV-504	**Battery and Battery Management System**	**[3-0-0]**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓						✓
CO2	✓	✓	✓		✓	✓	
CO3	✓	✓	✓		✓	✓	
CO4	✓	✓	✓	✓		✓	✓

Course Outcome: On successful completion of this course the student will be able to:

1. **Interpret the role of battery management system.**
2. **Identify the requirements of Battery Management System.**
3. **Understand the concept associated with battery charging / discharging process.**
4. **Design of various parameters of battery and its modelling.**

General introduction to battery management system, need for BMS, BMS making storage system efficient safe and dependable, Basic function of BMS, Energy control Management, Customized battery management system, standards for BMS development.

Schemes of Battery Testing: standardization of characteristic tests, capacity and charge and discharge rate test, battery cycle test, fixed rate cycle test method.

Battery Modelling: purpose of battery modelling, non-circuit models, equivalent circuit models, third order RC network, estimation of model parameters.

SoC Estimation of Battery: relation between SoC, SoP, SoE, classic estimation methods, Open circuit method, difficulty in SoC estimation, common complicated estimation method, Estimation error.

Charge Control: Charge control methods, effect of charge control on battery performance, charging circuits, key indicators of charging characteristics, Constant current and constant voltage charging method, fast charging, ultra-fast charging.

Design of battery parameters measurement system, safety control, stability of BMS, Battery fault diagnosis.

<u>Text Books</u>

1 Fundamentals and Applications of Lithium-ion Batteries in Electric Drive Vehicles By Jiuchun Jiang, Caiping Zhang
2 Battery Management System and Its Applications By Xiaojun Tan, Andrea Vezzini, Yuqian Fan, Neeta Khare, You Xu, Liangliang Wei

EEEV-506	**Advanced Control System for Electric Vehicles**	**[3-0-0]**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓	✓	✓		✓	✓
CO2	✓	✓	✓		✓	✓	
CO3	✓	✓	✓		✓	✓	
CO4	✓	✓	✓		✓	✓	

Course Outcome: On successful completion of this course the student will be able to:

1. **Understand the importance of control in EV.**
2. **Introduction to model-based control designs.**
3. **Model predictive control and Sliding mode control for EV.**
4. **Understand the stability analysis of Evs under various control designs.**

Module 1: Introduction to System modelling: Importance of control system in electrical vehicle, Study of control architecture in electric vehicle. Fundamental studies of Modelling of vehicle dynamics and control.

Module 2: System Simulation and Validation: System simulation, advantages and disadvantage, steps in simulation study, Simulation of Mechanical and Electrical Systems. Introduction to modelling and Simulation for Software-in-Loop (SIL) and Hardware-in-Loop (HIL).

Module 3: Model based Control Approach: Introduction to the PID controller and its variants, Internal Model Control (IMC) and Polynomial Control Design. Introduction to model-based control designs for dc-dc converters, electric vehicle and hybrid electric vehicle control.

Module 4: Model Predictive Control: Predictive control strategy, prediction model, constraint handling prediction equations, unconstrained optimization, infinite horizon cost incorporating constraints, and quadratic programming. Its applications in control design for electric vehicle and hybrid electric vehicle control, autonomous system.

Module 5: Sliding Mode Control: Notion of variable structure systems and sliding mode control, Design of sliding mode control and chattering issue. Its applications in control design for dc-dc converters, electric vehicle and hybrid electric vehicle control.

Module 6: Stability Analysis: Stability concept, Stability definition in the sense of Lyapunov, Lyapunov stability theorems, electric vehicle stability analysis under various control designs

EEEV-508	**Special Electrical machines and Control**	**[3-0-0]**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓		✓		✓		✓
CO2	✓	✓	✓	✓	✓	✓	✓
CO3		✓	✓	✓		✓	✓
CO4			✓	✓			

Course Outcome: On successful completion of this course the student will be able to:

1. **Difference different special machines for electric vehicle application.**
2. **Evaluate the performance of special machines for EV.**
3. **Determine the special machine and their drive requirement for EV application**
4. **Analyze the performance of multiphase machine for EV.**

Permanent Magnet (PM) Brushless Motor Drives: Principle of PM brushless machines, Modelling of PM brushless machines, Inverters design and control, Design criteria of PM brushless motor drives for EVs, Design examples of PM brushless motor drives for EVs, Application, advantages and limitations for EVs.

Switched Reluctance Motor Drive: Structure of SR Machines, Principle of SR Machines, SR Converters Topologies, SR Motor Control, Design Criteria of SR Motor Drives for EVs, Examples of SR Motor Drives for EVs, Application, Advantages and Limitations for EVs.

Stator-PM Motor Drives Doubly-Salient PM Motor Drives, Flux-Reversal PM Motor Drives, Flux-Switching PM Motor Drives, Hybrid-Excited PM Motor Drives Flux-Mnemonic PM Motor Drives, Design criteria of Stator-PM motor drives for EVs, Application, advantages and limitations for EVs.

Magnetic-Geared Motor Drives: Principle of MG machines, Modeling of MG machines, Inverters for MG motors, MG motor control, Design criteria of MG motor drives for EVs, Application, advantages and limitations for EVs

Advanced Magnetless Motor Drives: Introduction of advanced magnetless technology, Synchronous reluctance motor drives, Doubly-Salient DC motor drives, Flux-switching DC motor drives, Design criteria of advanced magnetless motor drives for EVs, Application, advantages and limitations for EVs.

Multiphase Motor Drives: Multiphase Induction motor drives principle, Operation and control, Multiphase PMSM machine principle, operation and control, Fault tolerant operation of multiphase drives

<u>Text book</u>

1. Mehrdad Ehsani, Yimin Gao, Sebatien Gay and Ali Emadi, “Modern Electric, Hybrid Electric and Fuel cell vehicles: Fundamentals, Theory and Design”, CRC Press.
2. Iqbal Husain, “Electric and Hybrid Vehicles- Design Fundamentals” CRC Press, 2011.
3. James Larminie and John Loury, “Electric Vehicle Technology – Explained”, John Wiley & Sons Ltd,

EEEV-528	**Electric Vehicle Laboratory**	**[0-0-3]**

Course Outcome: On successful completion of this course the student will be able to:

1. **Gain knowledge and expertise in Simulink to control electric drives.**
2. **Understand the operation of controlled Real time simulator.**
3. **Operation and control of three phase motor drives.**

At least 8 experiments are to be performed out of the following Suggested List of Experiments:

Suggested List of Experiments:

1. To study battery charging/ discharging using BMS
2. To operate and control BLDC motor and study its characteristic with load.
3. To operate and control SR motor and study its characteristic with load.
4. To operate and control PMSM motor and study its characteristic with load
5. To study the real time behaviour of battery using battery simulator for charging and discharging
6. Design and testing of battery and Motor.
7. Simulate, single phase, three phase Inverter with current controlled PWM technique.
8. Micro controller based PWM pulse generation for motor control
9. Speed control of real time Three phase converter-controlled dc motor drive.
10. Speed control of 3-phase AC voltage controller fed induction motor drive.

11 Induction motor drive control using flying capacitors multi-level inverter.
12 Speed control of a three- phase slip ring Induction motor by Static Rotor Resistance Control.
13 Speed control of a three- phase induction motor drive using vector control method.
14 FPGA based dc motor control
15 Analysing three phase Inverter with current controlled PWM technique with real time simulator.
16 Modeling and control of DC Motor with hardware and loop.
17 Speed control of 3-phase AC voltage controller fed induction motor drive using real time simulator.

The list of experiments given above is only suggestive. The Instructor may add new experiments as per the requirement of the course

EEEV-522	Digital Signal Processing Laboratory	[0-0-3]

Course Outcome: On successful completion of this course the student will be able to:

1 **Knowledge of standard signals and their plotting on MATLAB**
2 **Understanding of the concepts like convolution, cross-correlation, FFT and their application in signal processing.**
3 **Ability to design of different types of analog/ digital filters.**
4 **Ability to use signal processing techniques to filter noise from an ECG signal.**

Suggested List of Experiments:

1 Plot of standard signal waveforms
2 To compute convolution of two discrete-time signals
3 To compute convolution of two continuous signal using your own code
4 To compute cross-correlation of two discrete time signals
5 To compute FFT of a signal and noise-mixed signal
6 To design of Butter-Worth Filter (Analog/Digital domain)
7 To design of Chebyshev Filter (Analog/Digital domain)
8 Filter design using “FIR1”, “FIR2” and using “FDA tool”
9 File handling in Matlab.
10 Filtering of noise-mixed ECG Signal

The list of experiments given above is only suggestive. The Instructor may add new experiments as per the requirement of the course

Program Electives

EEEV-550	State Space Modeling and Control	[3-0-0]

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓	✓			✓		✓
CO2	✓	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓		✓	✓	✓
CO4			✓	✓			

Course Outcome: On successful completion of this course the student will be able to:

1. **Understand linear system theory**
2. **Understnad control system design in time and frequency domain**
3. **Understand control system design in state space**
4. **Understand nonlinear control concepts**

Module-1: Linear spaces and linear operators: fields, vectors and vector spaces; linear independence, dimension of linear space; inner product of vectors, quadratic functions and definite matrices, vector and matrix norms, scalar product and norm of vector functions; range space, rank, null space and nullity of a matrix, homogeneous equation, non-homogeneous equation; eigenvalues, eigenvectors, generalized eigenvectors, similarity transformation, Canonical form representation of linear operators, diagonal for representation of linear operator, Jordan form matrix representation of linear operator; Cayley-Hamilton theorem.

Module-2: Review of time domain and frequency domain responses, analysis of time and frequency domain common tools, time and frequency domain specifications, and their relationship; design of lag-lead compensator; PID controller tuning.

Module-3: Review of state space representations, controllable canonical form, observable canonical form, diagonal form; solution of vector-matrix differential equation, modal decomposition.

Module-4: Concept of controllability, observability, and their significance; state feedback controller; full order and reduced order observer design; observer-based state feedback controller.

Module-5: Introduction to non-linear system, common differences with linear system; concept of linearization; describing function of common nonlinearities.

Module-6: Lyapunov's concept of stability, asymptotically stable, uniformly asymptotically stable, uniformly asymptotically stable in the large, instability; Lyapunov function, Lyapunov’s theorems, stability analysis of linear and non-linear systems using Lyapunov concept.

Module-7: Phase plane analysis, classification of singular points, limit cycle and closed trajectory; stability analysis using phase plane; stability analysis using describing function.

Text Books

1 Linear Systems, Thomas Kailath, Prentice Hall
2 Modern Control Theory, William L. Brogan, 3 rd Edition Pearson
3 Control Systems – Principles and Design, Modan Gopal, C H Houpis, Tata McGraw Hill.
4 Linear Control System – Analysis and Design – Conventional and Modern, Johm J D’Azzo, C H Houpis, McGraw Hill International Edition.
5 Modern Control System Theory, M. Gopal, New Age Int.(P) Limited.

EEEV-551	**Hybrid Vehicle Technology**	**[3-0-0]**

Introduction to Hybrid vehicle Technology: Background on need for alternate vehicle technologies for propulsion; Emissions from IC engine-based transportation and regulating standards; Projections on availability of non-renewable energy sources; alternate technologies for vehicles for reducing urban pollution and for extending availability of resources; Importance of Hybrid Electric Vehicles technology.

Basics of vehicle propulsion: Components comprising traction torque; Vehicle performance parameters; speed, gradeability and acceleration; Fuel economy in IC engine vehicles; Torque – speed characteristics of IC engines. Comparison of Electric motors and IC engines as vehicle propulsion power sources.

Electric vehicle control: Basics of Electric vehicles; Types of Motors and the speed – torque characteristics; Different types of Batteries for Electric vehicles - Lead acid batteries, Nickel Metal Hydride Batteries, Lithium-ion batteries; comparison of different types of batteries; vehicle distance range per charge on vehicles; Battery charging systems; Battery Management systems. Motors and controllers; DC motors, principle and control, Induction motor drives; Methods of speed control of Induction motor; Constant V / f control, Vector control method; Inverter for Vector control; Basic principles of BLDC motors; Performance analysis and control of BLDC motors; sensor less technique for driving BLDC motors; Regenerative braking with electric drive; Four quadrant operation; optimizing energy recovery.

Architectures for Hybrid Electric vehicles: Series, parallel and series – parallel hybrids; Different architectures for Hybrid Electric vehicles; Series Hybrid Electric vehicle basics; Sizing of major components; Peak power sourcing. Parallel Hybrid electric vehicle basics; engine on / off control strategy; Peak power sourcing; drive train rating; Parallel Mild hybrid Electric drive system; series-parallel mild hybrid electric vehicle system.

Industry examples of Hybrid Electric vehicles: Fuel cell: Basic principles of fuel cells; Types of fuel cells and applications; PEM fuel cells for automobiles; architecture of a fuel cell electric and Fuel cell hybrid electric vehicles;

Text Books:

1. Modern Electric, Hybrid Electric and Fuel cell vehicles - by Mehrdad Ehsani, Yimin Gao, Sebatien
Gay and Ali Emadi; Published by CRC press.
2. Automotive Electronics Handbook – Edited by Ronald Jurgen;

EEEV-552	**Plug in Electric Vehicle**	**[3-0-0]**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓		✓			✓	
CO2	✓	✓	✓	✓	✓		
CO3	✓	✓	✓	✓	✓	✓	✓
CO4		✓		✓	✓	✓	✓

Course Outcome: On successful completion of this course the student will be able to:

1. **Learn the charging strategy and options of EVs in view of various aspects.**
2. **Analysis of the efects of EVs on Power System with case studies.**
3. **Understand the voltage support and frequency regulation of integrated EVs.**
4. **Develop knowledge of external aspects that impact EV charging facility planning and V2G aggregator design.**

Introduction, Impact of charging strategies, EV charging options and infrastructure, energy, economic and environmental considerations, Impact of EV charging on power grid, effect of EV charging on generation and load profile, Smart charging technologies, Impact on investment.

Influence of EVs on Power System: Introduction, identification of EV demand, EV penetration level for different scenarios, classification based on penetration level, EV impacts on system demand: dumb charging, multiple tariff charging, smart charging, case studies.

Frequency Control Reserves & Voltage Support from EVs: Introduction, power system ancillary services, electric vehicles to support wind power integration, electric vehicle as frequency control reserves and tertiary reserves, voltage support and electric vehicle integration, properties of frequency regulation reserves, control strategies for EVs to support frequency regulation.

EC Charging Facility Planning: Energy generation scheduling, different power sources, fluctuant electricity, centralized charging schemes, decentralized charging schemes, energy storage integration into Microgrid,

Design of V2G Aggregator.

Text Books

1 W.H, Anglin D.L, "Automotive Transmission and Power Train construction", McGraw Hill,

EEEV-553	**Advanced Composite Materials for Automobiles**	[3-0-0]

Course modules:

1. Introduction to composite materials: Reinforcement materials, matrix materials, fillers used in the composites
2. Theories of stress transfer in the composites
3. Raw material selection strategies for composite development
4. Textile reinforcements: 2D and 3D woven structures, knitted and nonwoven reinforcements
5. Advanced 3D integrally woven structures as reinforcement for composites
6. Design and development of textile waste-based reinforcements for composite
7. Composite manufacturing processes
8. Characterization of composite materials
9. Selection of composite materials for automobile component design
10. Advanced composite materials: Composites for energy storage, micro air vehicles for surveillance
11. Development of advanced composite materials

Text Books:

1 Kaw A, “Mechanics of Composite Materials” Taylor & Francis, 2005.
2 Jones R, “Mechanics of Composite Materials” CRC Press, 2018.
3 Reinhart T J, “Introduction to Composites”, in Engineering Materials Handbook, Vol.1, Composites, ASM International.
4 Chau T, and Ko F K, eds., “Textile Structural Composites”, Elsevier, 1989

EEEV-554	**Energy Energy Storage Technologies**	[3-0-0]

Energy Sources in EV and HEV systems: Electrochemical Batteries – Terminology, Specific Energy, Specific Power, Energy Efficiency in Lead-Acid Batteries, Nicked based batteries, Lithium based batteries, Requirement of Ultracapacitors – Features, Principle of operation and Performance of UC, High Speed Flywheels – Operating Principles, Power capacity, Flywheel technologies, Hybrid Energy Storage Systems, Fuel Cell – Principle of Operation and Performance

Fuel Cells for Automotive Applications: Basic Concepts of Electrochemistry - Proton Exchange Membrane Fuel Cells: Membrane, Electrocatalysts, GDL, Bipolar Plates - Sensitivity of PEM Stacks to Operating Conditions: Polarization Curve, Effect of Operative Parameters on the Polarization Curve - Durability of PEM Fuel Cells.

Design Of Hydrogen Fuel Cell Systems for Road Vehicles: Hydrogen Fuel Cell Systems: Preliminary Remarks - Hydrogen Feeling System - Air Feeding System - Thermal Management System - Water/Humidification Management System - Integrated Fuel Cell System: Efficiency, Dynamics, Costs.

EEEV-555	**Optimization Techniques**	[3-0-0]

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓					✓	
CO2	✓	✓	✓	✓	✓		
CO3	✓	✓		✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓

Course Outcome: On successful completion of this course the student will be able to:

1. Demonstrate understanding of different optimization techniques

2. Model the optimization problems for various practical situations

3. Make decisions about selecting appropriate optimization method

4. Utilize advanced optimization algorithms for solving complex optimization problems.

Introduction - Review of linear programming techniques

Multi objective optimization- Basics of Optimization , transportation and assignment problem, network techniques

Non-Linear Programming - Introduction to non-linear programming- constrained and unconstrained optimization problem, Kuhn-Tucker conditions

Quadratic Programming – Introduction to Quadratic and separable programming.

Advanced optimization techniques- particles swarm optimization, genetic algorithm

Introduction to convex optimization problems, recent work on Optimization techniques

Text Books

1 HamdyA.Taha, “Operational research-An Introduction", Tenth Edition, 2019
2 SS Rao, “Optimization theory and applications”, 3rd Edition, New Age International, 2010.

EEEV-556	**Soft Computing and Intelligent Systems**	[3-0-0]

Introduction – Introduction to Soft Computing, Need of Soft computing, Comparison between

soft and Hard computing techniques

Intelligent Control- need for intelligent control, Introduction to intelligent system modeling

using Fuzzy logic, Basic Fuzzy Logic System, Fuzzy Logic based system modeling, Fuzzy Logic based Controller Design

Neural Network - Theoretical and implementation issues, artificial neural network based

system modeling and controller design: theoretical and implementation issues

Neuro-fuzzy systems- Introduction to neuro-fuzzy system and their application to control of

complex systems, Industrial Case studies

Text Books

1 T.J. Ross, “Fuzzy Logic Control”, 4th Edition, Wiley Publications, 2016.
2 Drinnkov, “Fuzzy Logic Control”, Narosa Publishers, 2008.
3 Simon Hekins, “Comprehensive Neural Networks”, Pearson Publications, 2010.
4 J.S.R. Jang, C.T. Sun, E. Mizutani, “Neuro Fuzzy and Soft Computing”, P.H.I. Publishers, 2000.

EEEV-557	**System Modeling and Reliability**	[3-0-0]

System Models and Studies: Concept of a system, system Environment, stochastic Activities, continuous and discrete systems, systems modeling, types of models, Principles used in Modeling, system Analysis & design.

System Representation: Introduction, Block diagram presentation, Standard Block – Diagram, Signal flow graphs, Determination of overall system response using Block diagram and Signal flow for the various inputs.

System Equations: Introduction, Electric circuits and components, Basic linear algebra, state concept, Mechanical Translation system, analogous circuits, Mechanical rotational system.

Probability concepts in simulation: Stochastic variables, discrete probability functions, continuous probability functions, Measures of probability. Functions, numerical evaluation of continuous probability functions, Estimation of mean variances, and Correlation, Random number.

System Simulation: Step in simulation study, techniques of simulation, comparison of simulation and analytical methods, Experimental Nature of simulation, types of system simulation, Numerical computation Technique for continuous models, Numerical computation technique for Discrete models, Distributed lag models, Real Time Simulation, Selection of Simulation Software, Simulation Packages, Trends in simulation software.

Introduction to system Reliability: Reliability, MTTF, MTBF, failure data analysis, hazard rate, System reliability using: - series configuration, parallel configuration, mixed configuration, Markov model, fault tree analysis. Reliability improvement and maintainability.

Different Case studies using soft computing algorithm.

Text Books

1. Nagrath IJ and Gopal M, "System Modeling and Analysis," Tata McGraw-Hill
2. Srinath LS, "Reliability Engineering," East West Press.
3. Gorden G, "System Simulation," Prentice Hall
4. Law AM and Kelton WD, "Simulation Modeling and Analysis," Tata McGraw-Hill
5. Banks J, Carson JS, Nelson BL and Nicol DM, "Discrete Event System Simulation," Prentice Hall

EEEV-558	**Nonlinear Analysis and Control of Power Electronic Converters**	**[3-0-0]**

Overview of basic and advanced Power electronic converters, various applications, basics of utility power conversion, isolated and non-isolated converter circuits, types of power converter models.

Steady state converter analysis, Steady state modeling of the power converters, DC transformer model, loss modeling.

Dynamic modeling of the power converters, AC modeling of converters, state-space averaging, Transfer functions and frequency domain analysis, Extra Element Theorem.

Pulse Width Modulation (PWM) control of power converters, voltage source and current source inverters,

Feedback control design, voltage mode and current mode control, control of inverters and rectifiers

Analog and digital implementation of the controllers, Advanced analysis and control techniques applied to power electronics converters.

Text Books

1 R. W. Erickson, D. Maksimovic, Fundamentals of Power Electronics, Kluwer Academic Publishers, 2004. I. Batarseh, Power Electronic Circuits, Wiley, 2004.
2 J. Kassakian, M. F. Schlecht, and G. C. Verghese, Principles of Power Electronics, Addison-Wesley Publishing Company, 1991.

EEEV-559	**Power Quality Problems and Mitigation Techniques in Microgrids**	**[3-0-0]**

Terms and definitions & Sources – Overloading, under voltage, over voltage - Concepts of transients - Short duration variations such as interruption - Long duration variation such as sustained interruption - Sags and swells - Voltage sag - Voltage swell - Voltage imbalance – Voltage fluctuations - Power frequency variations - International standards of power quality – Computer Business Equipment Manufacturers Associations (CBEMA) curve.

Estimating voltage sag performance - Thevenin's equivalent source - Analysis and calculation of various faulted condition - Estimation of the sag severity - Mitigation of voltage sag, Static transfer switches and fast transfer switches. - Capacitor switching – Lightning - Ferro resonance - Mitigation of voltage swell.

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

Principle of Operation of Passive Shunt and Series Compensators, Analysis and Design of Passive Shunt Compensators Simulation and Performance of Passive Power Filters- Limitations of Passive Filters Parallel Resonance of Passive Filters with the Supply System and Its Mitigation. Fundamentals of load compensation – voltage regulation & power factor correction.

Monitoring considerations - Monitoring and diagnostic techniques for various power quality problems - Quality measurement equipment - Harmonic / spectrum analyzer - Flicker meters Disturbance analyzer - Applications of expert systems for power quality monitoring. Principle & Working of DSTATCOM – DSTATCOM in Voltage control mode, current control mode, DVR Structure – Rectifier supported DVR – DC Capacitor supported DVR - Unified power quality conditioner.

<u>Text Books</u>

1 Roger. C. Dugan, Mark. F. Mc Granagham, Surya Santoso, H.WayneBeaty, “Electrical Power Systems Quality”, McGraw Hill, 2003.

2 Bhim Singh, Ambrish Chandra, Kamal Al-Haddad,” Power Quality Problems & Mitigation Techniques” Wiley, 2015.

EEEV-560	Virtual Instrumentation					[3-0-0]
	PO1	PO2	PO3	PO4	PO5	PO6	PO7

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✔	✔	✔	✔		✔	✔
CO2	✔	✔	✔	✔		✔	✔
CO3	✔	✔	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔	✔	✔

On successful completion of this course the student will be able to:

CO 1. Understand and explore concepts of virtual instrumentation technology, hardware-software components, role of LabVIEW, and applications areas.

CO 2. Develop LabVIEW programming skills to code virtual instruments for solving different problems.

CO 3. Analyze data acquisition, signal processing -analysis, data visualization and connectivity techniques and methods in LabVIEW for different applications.

CO 4. To design and develop a VI system with LabVIEW programming for varied real-world measurement, testing, control and automation applications

Introduction: Definition, comparison with hard wired instruments, VI architecture, block diagram representation, VI application softwares, salient features and application areas.

LabVIEW basics: Introduction, building front panel and block diagram, tools and palettes, creating subVI, Controlling program flow – Loops, structures, shift registers, local and global variables, data types- Numeric, digital, strings, arrays, clusters, waveform, data presentation elements, graphs and charts.

LabVIEW advance: File input – output, timing and synchronization, mathematical analysis function. Data communication functions, programmatically controlling VIs

Data acquisition basics: Classification of signals, analog I/O and digital I/O signal acquisition, study different types of data acquisition system (USB, PCI, RS-485 network based).

LabVIEW data acquisition and instrument control: Study of various functions, Interfacing DAQ system with LabVIEW, Building VIs for analog I/O and digital I/O, study of VIs, control of instruments and DAQ system using serial, RS-485 and GPIB interface.

Software signal processing and manipulation: Sampling theorem, anti-aliasing filters, time and frequency domain analysis, Windowing, signal generation, spectrum analysis, digital filtering.

Case study: Development of VIs for specific application (simulation, real time)

Text Books

1. Wells LK, “LabVIEW for everyone – Graphical Programming made even easier,” Prentice Hall
2. Gupta S and Joseph J, “Virtual Instrumentation using LabVIEW,” Tata McGraw Hill

Reference Books

3. Johnson GW, “LabVIEW graphical Programming- Practical application in instrumentation and Control,” Tata McGraw-Hill

4. Ritter DJ, “LabVIEW GUI- Essential Techniques,” Tata McGraw-Hill

5. National Instruments, “LabVIEW-User Manual,” National Instruments Corporation

EEEV-561	Introductin to Data Analytics						[3-0-0]
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✔						
CO2	✔		✔	✔		✔	✔
CO3	✔				✔		✔
CO4			✔				

Course Objective: The objective of this course is to develop in depth understanding of the key technologies in data science and business analytics: data mining, machine learning, visualization techniques, predictive modeling, and statistics.

Course Outcome:

CO-1: Acquire a fundamental understanding of the analytical techniques and software tools necessary to effectively generate useful information from structured and unstructured data

CO-2:Gain experience in using the tools and techniques of data science for real world problems and add significant value in professional setting.

CO-3: To apply computing theory and algorithms, as well as mathematical and statistical models to appropriately formulate and use data.

CO-4: Able to utilize knowledge and skills to continue learning and adapting to new data science technologies

Course Content:

Introduction to Data Science, Evolution of Data Science, Data Science Roles, Applications of Data Science in various fields, Bivariate normal distribution, types, importance, methods of measuring correlation-scatter diagram, Karl Pearson's Coefficient of Correlation and Spearman's rank Correlation. Regression lines, Difference between regression and correlation, uses of Regression

Classification and Prediction: Basic Concepts of logistic regression, Bayesian Classification – Rule Based Classification, Classification by Backpropagation, Support Vector Machines, Associative Classification, Lazy Learners, Anamoly detection, Other Classification Methods

Clustering and Trends in Data Mining: Data Preprocessing, Cluster Analysis, Types of Data, Categorization of Major Clustering Methods, Kmeans, Partitioning Methods, Hierarchical Methods, Density-Based Methods, Grid Based Methods, Model-Based Clustering Methods-Evaluation Metrics

Dimensionality reduction: Principal component analysis and Singular value decomposition.

Time series modeling: Periodic regression, modeling trend, periodicity and local variations, ACF and PACF plots, ARIMA models, Additive and Multiplicative models.

Books:

1) Ethem Alpaydin, “Introduction to Machine Learning”, MIT Press, Third Edition, 2014.

2) Stephen Marshland, "Machine Learning: An Algorithmic Perspective", Chapman & Hall/CRC 2009.

3) Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar, "Foundations of Machine Learning", MIT

Press (MA) 2012.

4) Tom Mitchell, "Machine Learning", McGraw-Hill, 1997.