BIJU PATNAIK UNIVERSITY OF TECHNOLOGY, ODISHA
ROURKELA

CURRICULUM AND SYLLABUS

M.TECH
(ELECTRIC VEHICLE TECHNOLOGY)

From the
ADMISSION BATCH 2022-23

M.TECH IN ELECTRIC VEHICLE TECHNOLOGY
(ADMISSION BATCH : 2022-23)

FIRST SEMESTER		THEORY				PRACTICAL / SESSIONAL		
CODE	**COURSE NAME**	**HOURS/ WEEK L-T-P**	**CREDIT**	**UNIV. MARKS**	**INT. EVALUATION**	**HOURS/WEEK L-T-P**	**CREDIT**	**MARKS**
P1PGCC01	Computational Methods and Techniques	3-1-0	4	100	50	-	-	-
P1PGCC02	Internet of Things	3-1-0	4	100	50	-	-	-
V1EVBC03	Powertrain Architecture for Electric Vehicles	3-1-0	4	100	50	-	-	-
V1EVBC04	Vehicular Communication Networks	3-1-0	4	100	50	-	-	-
P1EVBC05	Smart Electrical Energy System	3-1-0	4	100	50	-	-	-
V1EVBL01	Lab I	-	-	-	-	0-0-4	4	150
V1EVBL02	Report Writing & Seminar (Entrepreneurship & Start Up)	-	-	-	-	0-0-4	4	150
Total		**-**	**20**	**500**	**250**	**-**	**8**	**300**
Total Marks : 1050								
Total Credits : 28								
Total Cumulative Credits : 28								

SECOND SEMESTER		THEORY				PRACTICAL / SESSIONAL		
CODE	**COURSE NAME**	**HOURS/ WEEK L-T-P**	**CREDIT**	**UNIV. MARKS**	**INT. EVALUATION**	**HOURS/ WEEK L-T-P**	**CREDIT**	**MARKS**
V2EVSC01	***Specialization Core – I*** Electric Vehicle Technology	3-1-0	4	100	50	-	-	-
V2EVSC02	***Specialization Core – II*** EV Batteries and Charging	3-1-0	4	100	50	-	-	-
	Elective I (Specialization related)	3-1-0	4	100	50	-	-	-
V2EVEL01	1. Machine Learning for Autonomous Vehicles							
V2EVEL02	2. Intelligent Control Techniques							
V2EVEL03	3. Vehicle Dynamics							
V2EVEL04	4. Special Machines for Electric Vehicles							
	Elective II (Department related)	3-1-0	4	100	50	-	-	-
V2EVEL05	1. Modelling and Simulation of EHV							
V2EVEL06	2. Smart Grid Interface of Electric Vehicles							
V2EVEL07	3. Testing and Certification of Electric and Hybrid Vehicles							
V2EVEL08	4. Sensor Systems for Electric Vehicles.							
	Elective III (from any Department)	3-1-0	4	100	50	-	-	-
P2PRCC12	1. Green Energy Resources & Technology							
P2PECC13	2. Quantitative methods for Energy Management & planning							
V2EVEL09	3. Electric Drives in Hybrid Vehicle							
V2EVEL10	4. Digital Control Systems							
V2EVBL01	Lab II	-	-	-	-	0-0-4	4	150
V2EVBL02	Design Project	-	-	-	-	0-0-4	4	150
Total		**-**	**20**	**500**	**250**	**-**	**8**	**300**
Total Marks : 1050								
Total Credits : 28								
Total Cumulative Credits : 56								

THIRD SEMESTER		THEORY				PRACTICAL / SESSIONAL		
CODE	**COURSE NAME**	**HOURS/ WEEK L-T-P**	**CREDIT**	**UNIV. MARKS**	**INT. EVALUATION**	**HOURS/ WEEK L-T-P**	**CREDIT**	**MARKS**
P3PGCC01	Research Methodology	3-1-0	4	100	50	-	-	-
P3PGCC02	IPR (Intellectual Property Rights)	3-1-0	4	100	50	-	-	-
V3EVBL01	Pre Dissertation Work Evaluation	-	-	-	-	-	9	200
Total		**-**	**8**	**200**	**250**	**-**	**9**	**200**
Total Marks : 650								
Total Credits : 17								
Total Cumulative Credits : 73								

FOURTH SEMESTER		THEORY				PRACTICAL / SESSIONAL		
CODE	**COURSE NAME**	**HOURS/ WEEK L-T-P**	**CREDIT**	**UNIV. MARKS**	**INT. EVALUATION**	**HOURS/ WEEK L-T-P**	**CREDIT**	**MARKS**
V4EVBL01	Dissertation Evaluation and Open Defence	-	-	-	-	-	17	500
Total		**-**	**-**	**-**	**-**	**-**	**17**	**500**
Total Marks : 500								
Total Credits : 17								
Total Cumulative Credits : 90								

P1PGCC01 COMPUTATIONAL METHODS AND TECHNIQUES

MODULE-I:
Neural Networks: Artificial Neural Network and Introduction, Learning Rules, Knowledge Representation and Acquisition, Different Methods of Learning.
Algorithms of Neural Network: Feed-forward Error Back Propagation, Hopfield Model, Kohonen's Featrure Map, K-Means Clustering, ART Networks, RBFN, Application of Neural Network to the relevant field.

MODULE-II:
Fuzzy Logic: Basic Concepts of Fuzzy Logic, Fuzzy vs Crisp Set, Linguistic variables, Membership Functions, Operations of Fuzzy Sets, Fuzzy If-Then Rules, Variable Inference Techniques, Defuzzification, Basic Fuzzy Inference Algorithm, Fuzzy System Design, FKBC and PID Control, Antilock Breaking System(ABS), Industrial Applications.

MODULE-III:
Optimization Fundamentals: Definition, Classification of Optimization Problems, Unconstrained and Constrained Optimization, Optimality Conditions.
LINEAR Programming: Simplex Method, Duality, Sensitivity Methods
NON-LINEAR Programming: Newton's Method, GRG Method, Penalty Function Method, Augmented Langrange Multiplier Method, Dynamic Programming and Integer Programming, Interior Point Methods, Karmakar's Algorithm, Dual Affine, Primal Affine.

MODULE-IV:
Genetic Algorithm: GA and Genetic Engineering, Finite Element based Optimization, PSO,BFO, Hybridization of Optimization Technique, Application of Optimization Technique for Solving Projects(Project solutions).
Implementation of Branch Relevant Industrial Applications by Matlab Code.

Books Recommended:

1. Neural Networks- by Simon Haykin
2. Fuzzy Logic with Engineering Application- by ROSS J.T (Tata Mc)
3. Neural Networks and Fuzzy Logic – by Bart Kosko
4. An introduction Fuzzy Control – by D.Driankor, H. Hellendorn, M.Reinfrank (Narosa Pub)
5. Fuzzy Neural Control – by Junhong NIE & Derek Linkers (PHI)
6. Related IEEE/IEE Publications
7. Fuzzy System Design Principles, Building Fuzzy IF-THEN Rule Bases – by Riza C. Berikiu and Trubatch, IEEE Press
8. Ashok D. Begundu & chandrapatla T.R "Optimization concept and application in engineering",Prentice Hall,1999
9. Rao S.S "Engineering Optimization"
10. Gill,Murray and Wright ,"Practical Optimization"
11. James A.Memoh. "Electric Power System Application Of Optimization".
12. Song Y.,"Modern Optimization Techniques In Power System"
13. Optimization Research;Prabhakar Pai,Oxford University Press.

P1PGCC02 INTERNET OF THINGS

MODULE-I: Introduction to Internet of Things
Introduction-Definition & Characteristics of IoT, Physical Design of IoT- Things in IoT, IoT Protocols, Logical Design of IoT- IoT Functional Blocks, IoT Communication Models, IoT Communication APIs, IoT Enabling Technologies- Wireless Sensor Networks, Cloud Computing, Big Data Analytics, Communication Protocols, Embedded Systems, IoT Levels & Deployment Templates.

MODULE-II:
Domain Specific IoTs
Home Automation: Smart Lighting, Smart Appliances, Intrusion Detection, Smoke/Gas Detectors, Cities-Smart Parking, Smart Lighting, Smart Roads, Structural Health Monitoring, Surveillance, Emergency Response, Environment-Weather Monitoring, Air Pollution Monitoring, Noise Pollution Monitoring, Forest Fire Detection, River Floods Detection, Energy- Smart Grids, Renewable Energy Systems, Prognostics, Retail-Inventory Management, Smart Payments, Smart Vending Machines, Logistics-Route Generation & Scheduling, Fleet Tracking, Shipment Monitoring, Remote Vehicle Diagnostics, Agriculture-Smart Irrigation ,Green House Control ,Industry -Machine Diagnosis & Prognosis Indoor Air Quality Monitoring ,Health & Lifestyle -Health & Fitness Monitoring, Wearable Electronics
IoT and M2M Introduction, M2M-Difference between IoT and M2M, SDN and NFV for IoT-Software Defined Networking, Network Function Virtualization

MODULE-III:
IoT Platforms Design Methodology
IoT Design Methodology-Purpose & Requirements Specification,Process Specification, Domain Model Specification, Information Model Specification, Service Specifications, IoT Level Specification, Functional View Specification, Operational View Specification, Device & Component Integration, Application Development, Case Study on IoT System for Weather Monitoring, Motivation for Using Python IoT Physical Devices & Endpoints
What is an IoT Device-Basic building blocks of an IoT Device, Exemplary Device: Raspberry Pi, About the Board, Linux on Raspberry Pi, Raspberry Pi Interfaces – Serial, SPI, I2C, Programming Raspberry Pi with Python-Controlling LED with Raspberry Pi, Interfacing an LED and Switch with Raspberry Pi, Interfacing a Light Sensor (LDR) with Raspberry Pi, Other IoT Devices- pcDuino, Beagle Bone Black, Cubieboard

MODULE-IV:
IoT & Beyond : Use of Big Data and Visualization in IoT, Industry 4.0 Concepts. Overview of RFID, Low-power design (Bluetooth Low Energy), range extension techniques (data mining and mesh networking), and dataintensive IoT for continuous recognition applications. Overview of Android / IOS App Development tools & Internet of Everything

Text Books:
1. Internet of Things, A Hands on Approach, by Arshdeep Bahga & Vijay audisetti, University Press.
Reference Books:
1. The Internet of Things, by Michael Millen, Pearson

V1EVBC03 POWERTRAIN ARCHITECHURE FOR ELECTRICAL VEHICLES

MODULE-I: Introduction to Powertrain (6 Hours)
Brief History of Electric Powertrain- energy sources for propulsion and emissions- regulatory considerations and emission trends-An overview of conventional, Battery, Hybrid, and Fuel Cell Electric Systems

MODULE-II: DC-DC Power Electronic Converters (10 Hours)
Non isolated DC-DC Converters – Introduction-Power Conversion-Common and Basic Principles-Analysis of Buck converter with CCM- Analysis of Boost converter with CCM-Passive components for power converters
Isolated DC-DC Converters – Introduction-Forward Converter-Full-Bridge Converter-Resonant Power Conversion

MODULE-III: DC-AC Power Electronic Converters (8 Hours)
Three phase inverters-modulationschemes, sinusoidal Modulation, Sinusoidal modulation with third harmonic addition–modulation index-inverter currents-switch, diode, and input average and RMS Currents-Inverter power loss-switching losses and conduction losses of IGBT module

MODULE-IV: Induction Motor Drives: (11Hours)
Introduction - Torque and Speed Control of Induction Motor - Basics of Power Electronics Control in Induction Motors - Induction Motor VSD Operating Modes - Fundamentals of Scalar and Vector Control for Induction Motors - Scalar Control - Vector Control - Field-Oriented Control - Direct Torque Control - Induction Motor Drives for Electric Vehicles

MODULE-V: Brushless DC Drives:(7 Hours)
BLDC Fundamentals-Control Principles and Strategies-Torque Production-Advantages and Disadvantages-Torque Ripple-Design Considerations-Finite Element Analysis and Design Considerations for BLDC.

TEXT BOOKS

1. John G. Hayes, G. AbasGoodarzi, Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles (ISBN: 978-1-119-06367-4)
2. Ali Emadi, Handbook of Automotive Power Electronics and Motor Drives, New York, NY: Marcel Dekker, ISBN: 0-8247-2361-9, May 2005.
3. Mohan, N., Undeland, T.M., and Robbins W.P., Power Electronics — Converters, Applications, and Design, 2nd Edition, John Wiley and Sons, Inc., New York, 1995.
4. B.K. Bose, Modern Power Electronics and AC Drives, Pearson Education (Singapore), 2002.
5. G.K. Dubey. Power Semiconductor Controlled Drives, 1st Ed. Englewood Cliffs, NJ: Prentice-Hall, pp. 345–349, 1989

V1EVBC04 VEHICULAR COMMUNICATION NETWORKS

MODULE-I: Introduction and Cooperative Vehicular Safety Applications:(6 Hours)
Basic Principles and Challenges, Past and Ongoing VANET Activities, Enabling Technologies, Cooperative System Architecture, VANET-enabled Active Safety Applications.

MODULE-II: Vehicular Mobility Modeling for VANET: (10 Hours)
Random Models, Flow Models – Microscopic flow models, Macroscopic flow models, Mesoscopic flow models, Lane changing models; Traffic Models – Trip planning, Path planning, Influence of time; Behavioral Models, Trace or Survey-based Models.

MODULE-III: Physical Layer & MAC Layer Considerations for Vehicular Communications: (11Hours)
Wireless Propagation Theory – Deterministic multipath models, Statistical multipath models, Path loss modelling; Channel Metrics – Delay spread, Coherence bandwidth, Doppler spread, Coherence time, Impact on OFDM systems; A Survey on Proposed MAC Approaches for VANETs - Time-division, Space-division, Code-division; Communication based on IEEE 802.11p.

MODULE-IV: Routing Protocols: (8 Hours)
Ad-hoc routing - Proactive routing protocols, Reactive routing protocols; Geographic routing - Geographic routing, Virtual-coordinate-based routing; Geocasting - ETSI GeoNetworking, Decentralized environmental notification messages, Topology-assisted geo-opportunistic routing.

MODULE-V: Standards and Regulations:(7 Hours)
Layered Architecture for VANETs - General concepts and definitions, A protocol stack for DSRC; DSRC Regulations, DSRC Physical Layer Standard, DSRC Data Link Layer Standard (MAC and LLC).

TEXTBOOKS

1. H. Hartenstein and K. P. Laberteaux, VANET: Vehicular Applications and Inter-Networking Technologies, Wiley, 2010.
2. ChirstophSommer, Falko Dressler, Vehicular Networking, Cambridge University Press, 2015.

REFERENCE BOOKS:

1. H. Moustafa, Y. Zhang, Vehicular Networks: Techniques, Standards, and Applications, CRC Press, 2009.
2. Claudia Campolo, AntonellaMolinaro and Riccardo Scopigno, Vehicular ad hoc Networks: Standards, Solutions, and Research, Springer, 2015.

P1EVBC05 SMART ELECTRICAL ENERGY SYSTEM

MODULE-I (7 Hrs)

Non-renewable reserves and resources; renewable resources, Transformation of Energy. Solar Power: Solar processes and spectral composition of solar radiation; Radiation flux at the Earth's surface. Solar collectors. Types and performance characteristics. Applications.

SOLAR THERMAL SYSTEM:Solar Collection Devices; their analysis; Solar Collector Characteristics; Solar Pond; application of solar energy to space heating etc.

MODULE-II (8 Hrs)

Wind Energy: Wind energy conversion; efficiency limit for wind energy conversion, types of converters, aerodynamics of wind rotors, power - speed and torque - speed characteristics of wind turbines, wind turbine control systems; conversion to electrical power: induction and synchronous generators, grid connected and self excited induction generator operation, constant voltage and constant frequency generation with power electronic control, single and double output systems, reactive power compensation

MODULE-III (15 Hrs)

Distributed Generation

Standards, DG potential, Definitions and terminologies; current status and future trends, Technical and economical impacts, Definitions and terminologies; current status and future trends, Technical and economical impacts DG Technologies, DG from renewable energy sources, DG from non-renewable energy sources, Distributed generation applications, Operating Modes, Base load; peaking; peak shaving and emergency power, Isolated, momentary parallel and grid connection

Distribution system performance and operation, Distribution automation and control, Voltage drop calculation for distribution networks, Power loss Calculation, Application of capacitors to distribution systems, Application of voltage regulators to distribution systems

MODULE-IV (15 Hrs)

Introduction to smart grid: Introduction to the smart grid, including objectives and functions, views of the smart grid within the industry, and design criteria.

Books Recommended:

1. S. N. Bhadra, D. Kastha, S. Banerjee, Wind Electrical Systems: Oxford Univ. Press, 2005.
2. S.A. Abbasi, N. Abbasi, Renewable Energy Sources and Their Environmental Impact: Prentice Hall of India, 2004.
3. S.P. Sukhatme - Solar Energy: Principles of thermal Collection and Storage,TMH,New Delhi
4. H.P. Garg and Jai Prakash - Solar Energy: Fundamentals and Applications,TMH
5. Ned Mohan et. al : Power Electronics ,John Wiley and Sons
6. P C Sen : Power Electronics , TMH
7. G K Dubey et. al :Thyristorised Power Controllers , Wiley Eastern Ltd.
8. B K Bose : Modern Power Electronics and AC Drives, Pearson Edn (Asia)

V2EVSC01 ELECTRIC VEHICLE TECHNOLOGY

MODULE-I : Introduction to Hybrid Electric Vehicle (6 Hours)
Review of Conventional Vehicle: Introduction to Hybrid Electric Vehicles: Types of EVs, Hybrid Electric Drive-train, Tractive effort in normal driving

MODULE-II : Electric Drives (10 Hours)
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

MODULE-III– Energy Storage (11 Hours)
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, Hybridization of different energy storage devices. Sizing the drive system, Design of Hybrid Electric Vehicle and Plug-in Electric Vehicle

MODULE-IV: Energy Management System (8 Hours)
Energy Management Strategies, Automotive networking and communication, EV charging standards, V2G, G2V, V2B, V2H. Business: E-mobility business, electrification challenges, Business- E-mobility business, electrification challenges

MODULE-V : Mobility and Connectors (7 Hours)
Connected Mobility and Autonomous Mobility- case study Emobility Indian Roadmap Perspective. Policy: EVs in infrastructure system, integration of EVs in smart grid, social dimensions of EVs.
Connectors- Types of EV charging connector, North American EV Plug Standards, DC Fast Charge EV Plug Standards in North America, CCS (Combined Charging System), CHAdeMO, Tesla, European EV Plug Standards

BOOKS RECOMMENDED :

1. Emadi, A. (Ed.), Miller, J., Ehsani, M., “Vehicular Electric Power Systems” Boca Raton, CRC Press, 2003
2. Husain, I. “Electric and Hybrid Vehicles” Boca Raton, CRC Press, 2010.
3. Larminie, James, and John Lowry, “Electric Vehicle Technology Explained” John Wiley and Sons, 2012
4. Tariq Muneer and Irene IllescasGarcía, “The automobile, In Electric Vehicles: Prospects and Challenges”, Elsevier, 2017
5. Sheldon S. Williamson, “Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles”, Springer, 2013

V2EVSC02 EV BATTERIES & CHARGING SYSTEM

MODULE- I: Battery parameters (6 Hours)
Cell and battery voltages, Charge (or Amphour) capacity, Energy stored, Energy density, Specific power, Amphour (or charge) efficiency, Energy efficiency, Self-discharge rates, Battery geometry, Battery temperature, heating and cooling needs, Battery life and number of deep cycles

MODULE-II: EV Batteries (8 Hours)
Lead Acid Batteries
Lead acid battery basics, Special characteristics of lead acid batteries, Battery life and maintenance, Battery charging, Summary Nickel-based Batteries Introduction, Nickel cadmium, Nickel metal hydride batteries

MODULE-III: Sodium, Lithium and Metal air batteries (10 Hours)
Sodium-based Batteries
Introduction, Sodium sulphur batteries, Sodium metal chloride (Zebra) batteries Lithium Batteries
Introduction, The lithium polymer battery, The lithium ion battery Metal Air Batteries
Introduction, The aluminium air battery, The zinc air battery

MODULE-IV: Charging Infrastructure (7 Hours)
Domestic Charging Infrastructure, Public Charging Infrastructure, Normal Charging Station, Occasional Charging Station, Fast Charging Station, Battery Swapping Station, Move-and-charge zone.

MODULE-V: EV Charging (11 Hours)
Battery Chargers: Charge equalisation, Conductive (Basic charger circuits, Microprocessor based charger circuit. Arrangement of an off-board conductive charger, Standard power levels of conductive chargers, Inductive (Principle of inductive charging, Soft-switching power converter for inductive charging), Battery indication methods

BOOKS RECOMMENDED :

1. James Larminie Oxford Brookes University, Oxford, UK John Lowry Acenti Designs Ltd., UK, Electric Vehicle Technology Explained
2. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001.
3. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
4. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
5. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

V2EVEL01 MACHINE LEARNING FOR AUTONOMOUS VEHICLES

MODULE-I: Introduction: (6 Hours)
Levels of autonomy in automobiles - Levels 0 through 5. Subsystems required for embedding intelligence into automobiles such as sensors, feedback control, software and hardware architecture etc. Sensors, perception and visualization for decision making

MODULE-II: Automotive Machine Learning for Autonomous Vehicles: (8 Hours)
Introduction – Types of Learning Paradigms: Supervised, and Unsupervised Learning, and their applications: object detection, object recognition, object classification, and object localization

MODULE-III: Supervised Learning: (10 Hours)
Classification (Detection and Classification of Objects, K-Nearest-Neighbour, Bayesian Classification: Naive Bayes, Decision Trees, Over fitting, Random Forests, SVM, Multiclass & Ordinal Classification, Kernels . Dimensionality Reduction: Feature Extraction & Selection
Regression: Instance based learning:, Linear Regression, Sensitivity Analysis, Multivariate Regression.: Linear Classification, Logistic Regression

MODULE-IV: Deep Learning for Self-Driving Cars: (11 Hours)
Perception: Camera, LiDAR, RADAR, Sensor Fusion.
Applications: Lane Line Detection, Road Segmentation, Obstacle Detection, Traffic-Signs/Light Detection, Road Marking, Distance Estimation, Driver Monitoring, Multi-Object Tracking.

MODULE-V: Decision making and trajectory planning: (7 Hours)
Principles of decision making- Heuristic approach and approximation approach; Trajectory planning: Graph based approach, Choice of best trajectory based on real-time data and tracking; various algorithms and their working principles for decision making and trajectory planning.

TEXTBOOKS:

1. Pattern Recognition and Machine Learning by Christopher Bishop
2. Machine Learning by Tom Mitchell
3. Autonomous Vehicle Driverless Self-Driving Cars and Artificial Intelligence: Practical Advances in AI and Machine Learning by Eliot et.al.
4. Applied Deep Learning and Computer Vision for Self-Driving Cars by SumitRanjan.
5. Machine Learning, Tom Mitchell, McGraw Hill, 1997.
6. Pattern Recognition and Machine Learning, Bishop, C. (2006), Berlin: Springer-Verla.

REFERENCES:

1. Introduction to Machine Learning, Ethem Alpaydin 2nd Edition.
2. Machine Learning for Hackers, Drew Conway & John Miles Wine.
3. Duda, Hart and Stork, Pattern Classification 2nd Edition Wiley Inter Science, 2000

V2EVEL02 INTELLIGENT CONTROL TECHNIQUES

MODULE-I: Introduction to control techniques: (6 Hours)
Need of intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule - based systems, the AI approach. Knowledge representation. Expert systems. Data Pre - Processing: Scaling, Fourier transformation, principal - component analysis and wavelet transformations.

MODULE-II: Artificial Neural Networks: (11 Hours)
Concept of Artificial Neural Networks and its basic mathematical model, McCulloch - Pitts neuron model, simple perceptron, Adaline and Madaline, Feed - forward Multilayer Perceptron. Learning and Training the neural network.
Networks: Hopfield network, Self - organizing network and Recurrent network. Neural Network based controller, Case studies: Identification and control of linear and nonlinear dynamic systems using Matlab / Neural Network toolbox.

MODULE-III: Genetic Algorithm: (8 Hours)
Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other than GA search techniques like tabu search and ant - colony search techniques for solving optimization problems.

MODULE-IV: Crisp sets and fuzzy sets: (7 Hours)
Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to Fuzzy logic modeling and control of a system. Fuzzification, inference and defuzzification. Fuzzy knowledge and rule bases.

MODULE-V: Fuzzy modeling and control schemes: (10 Hours)
Fuzzy modeling and control schemes for nonlinear systems. Self - organizing fuzzy logic control. Implementation of fuzzy logic controller using Matlab fuzzy - logic toolbox. Stability analysis of fuzzy control systems. Intelligent Control for SISO/MIMO Nonlinear Systems. Model Based Multivariable Fuzzy Controller.

TEXTBOOKS

1. Neural Networks: A comprehensive Foundation – Simon Haykins, Pearson Edition, 2003.
2. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and pai - PHI Publication.
3. Fuzzy logic with Fuzzy Applications – T.J Ross – Mc Graw Hill Inc, 1997.
4. David E Goldberg, Genetic Algorithms.

REFERENCES

1. Yegnanarayana B, “Artificial Neural Networks”, Prentice hall of India Private Ltd., New Delhi, 1999.
2. Zurada, J.M., „Introduction to Artificial Neural Systems‟, Jaico publishing house, Bombay, 1992.
3. Zimmermann, H.J., „Fuzzy set theory and its applications‟, Allied publishers limited, Madras, 2001.
4. M.T.Hagan, H. B. Demuth and M. Beale, Neural Network Design, Indian reprint, 2008.
5. Fredric M.Ham and Ivica Kostanic, Principles of Neurocomputing for science and Engineering, McGraw Hill, 2001.
6. N.K. Bose and P.Liang, Neural Network Fundamentals with Graphs, Algorithms and Applications, Mc - Graw Hill, Inc. 1996.
7. Yung C. Shin and Chengying Xu, Intelligent System - Modeling, Optimization and Control, CRC Press, 2009.
8. N.K.Sinha and Madan M Gupta, Soft computing & Intelligent Systems - Theory & Applications, Indian Edition, Elsevier, 2007.
9. John Yen and Reza Langari, Fuzzy logic Intelligence, Control, and Information, Pearson Education, Indian Edition, 2003.
10. Witold Pedrycz, Fuzzy Control and Fuzzy Systms, Overseas Press, Indian Edition, 2008.

V2EVEL03 VEHICLE DYNAMICS

MODULE-I: Introduction to Vehicle Dynamics and Acceleration Performance: (10 Hours)
Introduction to vehicle dynamics, Fundamental approach to modelling – Lumped mass, Vehicle fixed coordinate system, Motion variables, Earth fixed coordinate system, Euler angles, Forces, Newton's second law; Dynamic axle loads – Static loads on level ground, Low speed acceleration, Loads on grades; Power limited acceleration – Engines, Power train, Automatic transmissions; Traction limited acceleration – Transverse weight shift due to drive torque, Traction limits;

MODULE-II: Braking Performance: (7 Hours)
Basic equations – Constant deceleration, Deceleration with wind resistance, Energy, Power; Braking forces – Rolling resistance, Aerodynamic drag, Driveline drag, Grade; Brakes – Brake factor; Tire road friction – Velocity, Inflation pressure, vertical load;

MODULE-III: Road Loads: (8 Hours)
Mechanics of air flow around a vehicle, Pressure distribution on a vehicle, Aerodynamic forces, Drag components, Aerodynamic aids – Bumper spoilers, Air dams, Deck lid spoilers, Window and Pillar treatments, Optimization; Drag – Air density, Drag coefficient; Side force, Lift force, Pitching moment, Yawing moment, Rolling moment, Rolling resistance, Factors affecting rolling resistance, total road loads.

MODULE-IV: Steady State Cornering: (11 Hours)
Introduction, Low speed turning, High speed turning – Tire cornering forces, cornering equations, Understeer gradient, Characteristic speed, Critical speed, Lateral acceleration gain, Yaw velocity gain, Sideslip angle, Static margin; Suspension effects on cornering – Roll moment distribution, Camber change, Roll steer, Lateral force compliance steer, Aligning torque, Effect of tractive forces on cornering.

MODULE-V: Ride, Suspensions and Steering System: (6 Hours)
Frequency range of Ride and Noise, Excitation sources of Ride, Road roughness, Suspension isolation, Suspension stiffness, Suspension damping, Primary functions of suspension system, Four link, SLA front suspension, Multi link rear suspension, swing axle, Steering linkages, Steering geometry error, Front wheel geometry, Steering system forces and moments.

TEXTBOOKS:

1. Thomas D. Gillespie, Fundamentals of Vehicle Dynamics, Society of Automotive Engineers Inc, 1992.
2. Rajesh Rajamani, Vehicle Dynamics and Control, Springer, 2005.

REFERENCE BOOKS:

1. Reza N. Jazar, Vehicle Dynamics: Theory and Applications, Springer, 2008.
2. Hans B. Pacejka, Tyre and Vehicle Dynamics, Second Edition, Butterworth– Heinemann, 2006.
3. W.F. Milliken and D.L. Milliken, Race Car Vehicle Dynamics, SAE, 1995.

V2EVEL04 SPECIAL MACHINES FOR ELECTRIC VEHICLES

MODULE-I: Permanent Magnet (PM) Brushless Motor Drives: (11 Hours)
Structure of PM Brushless Machines, Principle of PM Brushless Machines Modeling of PM Brushless Machines, Inverters for PM Brushless Motors Motor 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.

MODULE-II: Switched Reluctance Motor drive: (6 Hours)
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.

MODULE-III: Stator-PM Motor Drives: (7 Hours)
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.

MODULE-IV: Magnetic-Geared Motor Drives: (8 Hours)
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

MODULE-V: Advanced Magnetless Motor Drives : (10 Hours)
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.

TEXTBOOKS:

1. K. T. Chau, Electric Vehicle Machines and Drives: Design, Analysis and Application, IEEE Press, Wiley, 2015.
2. Brushless Permanent magnet and reluctance motor drives, Clarenden press, T.J.E. Miller, 1989, Oxford.

REFERENCE BOOKS:

1. Mehrdad Ehsani, Yimin Gao, Sebatien Gay and Ali Emadi, Modern Electric, Hybrid Electric and Fuel cell vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2. James Larminie and John Loury, Electric Vehicle Technology – Explained, John Wiley & Sons Ltd, 2003.
3. T. Kenjo and S. Nagamori, 'Permanent Magnet and Brushless DC Motors', Clarendon Press, London,1988.

V2EVEL05 MODELLING AND SIMULATION OF EHV

MODULE-I : Modelling of Vehicle Performance Parameter (6 Hours)
Modelling Vehicle Acceleration - Acceleration performance parameters, modelling the acceleration of an electric scooter, modelling the acceleration of a small car.

MODULE-II : Modelling of Battery Electric Vehicles (10 Hours)
Electric Vehicle Modelling - Tractive Effort, Rolling resistance force, Aerodynamic drag, Hill climbing force, Acceleration force, Total tractive effort, Modelling Electric Vehicle Range - Driving cycles, Range modelling of battery electric vehicles, Constant velocity range modelling, Range modelling of fuel cell vehicles, Range modelling of hybrid electric vehicles

MODULE-III : Drivetrain Characteristics (11 Hours)
Modelling and Characteristics of EV/HEV Powertrains Components - ICE Performance Characteristics, Electric Motor Performance Characteristics - Battery Performance Characteristics- Transmission and Drivetrain Characteristics-Regenerative Braking Characteristics-Driving Cycles Modelling and Analysis of Electric and Hybrid Electric Vehicles Propulsion and Braking - Longitudinal Dynamics Equation of Motion - Vehicle Propulsion Modelling and Analysis - Vehicle Braking Modelling and Analysis

MODULE-IV : Energy Management (7 Hours)
Handling Analysis of Electric and Hybrid Electric Vehicles - Simplified Handling Models Energy/Power Allocation and Management - Power/Energy Management Controllers – RuleBased Control Strategies - Optimization-Based Control Strategies

MODULE-V : Fuel cells (8 Hours)
Control of Electric and Hybrid Electric Vehicle Dynamics - Fundamentals of Vehicle Dynamic Control (VDC) Systems, VDC Implementation on Electric and Hybrid Vehicles – Case Studies, Rechargeable Battery vehicles, Hybrid Vehicles, Fuel Cell Powered Bus

TEXTBOOKS

1. Amir Khajepour, Saber Fallah and Avesta Goodarzi, “Electric and Hybrid Vehicles Technologies, Modelling and Control: A Mechatronic Approach”, John Wiley & Sons Ltd, 2014.
2. Antoni Szumanowski, “Hybrid Electric Power Train Engineering and Technology: Modelling, Control, and Simulation”, IGI Global, 2013.
3. Mehrdad Ehsani, Yimin Gao, Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles_ Fundamentals, Theory, and Design, Second Edition”, CRC Press, 2010.
4. James Larminie, John Lowry, “Electric Vehicle Technology Explained”, John Wiley & Sons Ltd, 2003.

V2EVEL06 SMART GRID INTERFACE OF ELECTRIC VEHICLES

MODULE I: Introduction to the Smart Grid using EVs (6 Hours)
The Smart Grid and Microgrid, Impact of EVs on Distributed Energy Resources in the Smart Grid, V2G Technology and PEVs Charging Infrastructures.

MODULE-II: Impact of EV and V2G on the Smart Grid and Renewable Energy Systems (7 Hours)
Types of Electric Vehicles, Motor Vehicle Ownership and EV Migration, Impact of Estimated EVs on Electrical Network, Impact on Drivers and the Smart Grid

MODULE-III: Power Conversion Technology in the Smart Grid and EV (8 Hours)
Dynamical Modelling of EV Connected to Single-Phase Smart Grid Node, Dynamical Modelling of EV Connected to Three-Phase Smart Grid Node, Power Conversion Problem Formulation in Smart Grids with Evs.

MODULE-IV: Power Control and Monitoring of the Smart Grid with Evs (10 Hours)
Impacts of EV Penetration on Grid Power Profile and Requirements of Its Control and Monitoring Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid. Voltage and Frequency Regulation, Supporting and Balancing of Intermittent RES.

MODULE-V : EV Charging Technologies and V2G on Distributed Systems and Utility Interfaces (11 Hours)
Vehicle-to-Grid Concept and EV Communication Requirements, Distributed Generation and the Smart Grid, Charging Diversity and Utility Interfaces, Local, Central and Distributed Generation, Current PEV Charging Standards, Socket Types, Contact-Based PEV Charging, Rectifier Topologies for G2V, Inverter Topologies for V2G, DC/DC Converters.

TEXT BOOKS

1. Hossain, Jahangir Lu, Junwei, “Vehicle-to-Grid Linking Electric Vehicles to the Smart Grid,” Published by The Institution of Engineering and Technology, London, United Kingdom, 2015.
2. Qiuwei Wu, “Grid integration of Electric vehicles in Open electricity markets, ” John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, United Kingdom, 2013.
3. Canbing Li, Yijia Cao, Yonghong Kuang Bin Zhou, “Influences of Electric Vehicles on Power System and Key Technologies of Vehicle-to-Grid,” Jointly published with Science Press, Beijing and Springer-Verlag Berlin Heidelberg 2016.

V2EVEL07 TESTING AND CERTIFICATION OF ELECTRIC AND HYBRID VEHICLES

MODULE-I: INTRODUCTION (6 Hours)
Specification & Classification of Vehicles (including M, N and O layout), Homologation & its Types, Regulations overview (EEC, ECE, FMVSS, AIS, CMVR), Type approval Scheme, Homologation for export, Conformity of Production, various Parameters, Instruments and Types of test tracks, Hardware in The Loop (HIL) concepts for EV/HEVs.

MODULE-II: STATIC TESTING OF VEHICLE (7 Hours)
Photographs, CMVR physical verification, Tyre Tread Depth Test, Vehicle Weightment, Horn installation, Rear view mirror installation, Tell Tales, External Projection, Wheel Guard, Arrangement of Foot Controls for M1 Vehicle, Angle & Dimensions Measurement of Vehicle, The Requirement of Temporary Cabin For Drive– Away – Chassis, Electric vehicle – Safety Norms, Energy consumption and Power test.

MODULE-III: DYNAMICS TESTING OF VEHICLE (8 Hours)
Hood Latch, Gradeability, Pass-by Noise, Interior Noise, Turning Circle Diameter & Turning Clearance Circle Diameter, Steering Effort, Constant Speed Fuel Consumption, Cooling Performance, Speedo-meter Calibration, Range Test, Maximum Speed, Acceleration Test, Coast-down test, Brakes Performance ABS Test, Broad band / Narrow band EMI Test, Electric vehicle – Range Test.

MODULE-IV: VEHICLE COMPONENT TESTING (11 Hours)
Horn Testing, Safety Glasses Test: Windscreen laminated and toughened safety glass, Rear View Mirror Test, Hydraulic Brakes Hoses Fuel Tank Test: Metallic & Plastic, Hinges and Latches Test, Tyre & Wheel Rim Test, Bumper Impact Test, Side Door Intrusion, Crash test with dummies, Demist test, Defrost Test, Interior Fittings, Steering Impact test (GVW<1500 kg), Body block test, Head form test, Driver Field Of Vision, Safety belt assemblies, Safety belt anchorages, Seat anchorages & head restraints test, Airbag Test, Accelerator Control System, Motor power, Safety Requirements of Traction Batteries, EMI-EMC (CI, BCI, RE,RI and CTE).

MODULE-V: TESTS FOR HYBRID ELECTRIC VEHICLES, RETRO-FITMENT AND CHARGING STATION (10 Hours)
Hybrid Electric Vehicles Tests (M and N category), Tests for Hybrid Electric System Intended for Retrofitment on Vehicles of M and N Category (GVW < 3500 kg), Test for Electric Propulsion kit intended for Conversion, Test for Electric Vehicle Conductive AC Charging System, and Test for Electric vehicle conductive DC charging system.

TEXT BOOKS:

1. Bosch Automotive Handbook, Robert Bosch, 7th Edition, 2007
2. Vehicle Inspection Handbook", American Association of Motor Vehicle Administrators
3. Michael Plint& Anthony Martyr, "Engine Testing & Practice", Butterworth Heinmenn, 3rd ed, 2007
4. Proceedings- Automotive Testing & Certification held on 20th to 24th July 2010 at ARAI PUNE

V2EVEL08 SENSOR SYSTEMS FOR ELECTRIC VEHICLES

MODULE-I: Sensor fundamentals and characteristics (8 Periods)
Definitions, Classification of sensors and actuators, General requirements for interfacing, Performance characteristics of sensors and actuators

MODULE-II: Temperature & Optical sensors (9 Periods)
Temperature sensors: Thermoresistive sensors, Thermoelectric sensors, p–n junction temperature sensors.
Optical sensors: Quantum-based optical sensors, Photoelectric sensors, Charge coupled (CCD) sensors and detectors, Active far infrared (AFIR) sensors, Optical actuators.

MODULE-III: Electric, magnetic and mechanical sensors (10 Periods)
Electric and magnetic sensors: Capacitive sensors - Capacitive position, proximity, and displacement sensors, Inductive sensor, eddy current sensor, Hall effect sensor, Voltage and current sensors.
Mechanical sensors: Force sensor, Acceleration sensor, Pressure sensor, Velocity sensor.

MODULE-IV: Chemical, MEMS and smart sensors (9 periods)
Chemical sensors: Electrochemical sensors, Thermochemical sensors.
MEMS and smart sensors: MEMS sensors, Smart sensors, Wireless sensors and actuators and issues associated with their use, RFIDs and embedded sensors.

MODULE-V: Interfacing methods and circuits & Interfacing to microprocessors (6 periods)
Interfacing methods and circuits: Amplifiers, Power amplifiers, Digital circuits.
Interfacing to microprocessors: The microprocessor as a general-purpose controller, General requirements for interfacing sensors and actuators

Textbooks:

1. Nathan Ida, Sensors, Actuators and their interfaces, Second Edition, 2020, IET
2. Jacob Fraden, “Hand Book of Modern Sensors: physics, Designs and Applications”, 2015, 3rd edition, Springer, New York.

P2PRCC12 GREEN ENERGY RESOURCES & TECHNOLOGY

MODULE-I:
Solar photovoltaics: Introduction, Solar cell characteristics, Losses in solar cells, Modeling of solar cell, Solar PV modules, Bypass diode in PV module, Design of PV module, PV module power output, I-V curve of PV module, BOS of PV module, Batteries for solar PV, Battery charge controllers, DC-DC converters, DC-AC converters, MPPT, Different algorithm for MPPT, Types of PV system, Performance analysis of solar cell, Working of solar cell power plant.

MODULE-II:
Wind energy:Wind energy conversion, power ~ speed and torque ~ speed characteristics of wind turbines, wind turbine control systems; conversion to electrical power: induction and synchronous generators, grid connected and self excited induction generator operation, constant voltage and constant frequency generation with power electronic control, single and double output systems, reactive power compensation;
Ocean Energy: Ocean energy resources-ocean energy routes - Principles of ocean thermal energy conversion systems- ocean thermal power plants- Principles of ocean wave energy conversion and tidal energy conversion.

MODULE-III:
Biomass Energy: Introduction, Biomass conversion technology, Biogas, Composition of Biogas, Properties of Biogas, Biogas production reaction, Factor affecting biogas production, Biogas plant site selection, Biogas plants, Types of Biogas plants, Biogas purification, Biogas storage, Biogas dispensing, Advantages and disadvantages of Biogas, Emission from Biogas engines, Digester Filling and Biogas plant operation, Biogas digester sizing.

MODULE-IV:
Hybrid Power Syatems: Introduction, Need for hybrid systems, Range of hybrid systems, Types of Hybrid systems, Diesel-PV system, Wind-PV system, Micro hydel-PV system, Biomass-PV system, Electric vehicles, Hybrid electric vehicles.
Energy Conservation, Management and Economics: Impact of renewable energy on environment, Principle and strategies of energy conservation, energy management, energy audit, energy planning, Total energy system concept, Power tariff, Cost of electricity production from renewable.

Text / Reference Books:

1. S. N. Bhadra, D. Kastha, S. Banerjee, Wind Electrical Systems: Oxford Univ. Press, 2005.
2. S. S. Thipse, Non Conventional and Renewable Energy Sources, Narosa Publishing House, 2014.
3. S.A. Abbasi, N. Abbasi, Renewable Energy Sources and Their Environmental Impact: Prentice Hall of India, 2004.
4. S.P. Sukhatme - Solar Energy: Principles of thermal Collection and Storage,TMH,New Delhi
5. Duffic and Beckman - Solar Engineering of Thermal Processes, John wiley
6. Green Management and Green Technologies: Exploring the Causal Relationship by Jazmin Seijas Nogarida,2008.
7. Green Marketing and Management: A global Perspective by John F. Whaik, 2005

P2PECC13 QUANTITATIVE METHODS FOR ENERGY MANAGEMENT & PLANNING

MODULE-I:
A review of probability concepts, Forecasting and decision making in view of multi-variant techniques, Linear programming

MODULE-II:
Graphical solution, Simplex method, Duality and post-optimality analysis, Integer programming.

MODULE-III:
Optimal technology mix in micro and macro level energy planning exercises, Sequencing, Queuing theory, Networks, PERT and CPM

MODULE-IV:
Decision theory, Markov analysis, Non linear programming, Decision making with uncertainty, decision making with multiple objectives, Deterministic and probabilistic dynamic programming, Regression analysis.

Text/References

1. Operations Research, An Introduction, Sixth Edition, 2000, by HA Taha, Prentice-Hall of India Pvt. Ltd.
2. Quantitative Techniques in Management, First Edition, 1997, by ND Vohra, Tata McGraw-Hill Publishing Company Ltd, New Delhi.

V2EVEL09 ELECTRIC DRIVES IN HYBRID VEHICLE

MODULE-I : (11 Hours)
Introduction: History of hybrid vehicles, architectures of HEVs, series and parallel HEVs, complex HEVs. Hybridization of Automobile: Fundamentals of vehicle, components of conventional vehicle and propulsion load; Drive cycles and drive terrain; Concept of electric vehicle and hybrid electric vehicle; Plug-in hybrid vehicle, constituents of PHEV, comparison of HEV and PHEV; Fuel Cell Vehicles and its constituents.

MODULE-II : (10 Hours)
Plug-in Hybrid Electric Vehicle: PHEVs and EREVs, blended PHEVs, PHEV Architectures, equivalent electric range of blended PHEVs; Fuel economy of PHEVs, power management of PHEVs, end-of-life battery for electric power grid support, vehicle to grid technology, PHEV battery charging.

MODULE-III: (10 Hours)
Power Electronics in HEVs: Rectifiers used in HEVs, voltage ripples; Buck converter used in HEVs, non-isolated bidirectional DC-DC converter, regenerative braking, voltage source inverter, current source inverter, isolated bidirectional DC-DC converter, PWM rectifier in HEVs, EV and PHEV battery chargers.

MODULE-IV: (11 Hours)
Electric Machines and Drives in HEVs: Induction motor drives, Field oriented control of induction machines; Permanent magnet motor drives; Switched reluctance motors; Doubly salient permanent magnet machines.

Text Books/References:

1. Pistooa G., “Power Sources , Models, Sustanability, Infrstructure and the market”, Elsevier 2008
2. Mi Chris, Masrur A., and Gao D.W., “ Hybrid Electric Vehicle: Principles and Applications with Practical Perspectives”1995

V2EVEL10 DIGITAL CONTROL SYSTEMS

MODULE-I: INTRODUCTION (6 Hours)
Control System Terminology, Computer-Based Control: History and Trends, An Overview of the Classical Approach to Analog Controller Design.

MODULE-II: SIGNAL PROCESING IN DIGITAL CONTROL (10 Hours)
Configuration of the Basic Digital Control Scheme ,Principles of Signal Conversion, Discrete-Time Signals, Time-Domain Models for Discrete-Time Systems, The z-Transform, Transfer Function Models, Frequency Response, Stability on the z-Plane and the Jury Stability Criterion.

MODULE-III: SAMPLE-AND-HOLDSYSTEMS (8 Hours)
The Sampling operation, The Hold operation, Practical Sample-and-Hold Circuit, Sampled Spectra and Aliasing, Reconstruction of Analog Signals, Practical Aspects of the Choice of Sampling Rate, Principles of Discretization

MODULE-IV: MODELS OF DIGITAL CONTROL DEVICES AND SYSTEMS (11 Hours)
z-Domain Description of Sampled Continuous-Time Plants, z-Domain Description of Systems with Dead-Time, Implementation of Digital Controllers, Tunable PID Controllers, Digital Temperature Control System, Digital Position Control System, Stepping Motors and Their Control, Programmable Logic Controllers.

MODULE-V: DESIGN OF DIGITAL CONTROL ALGORITHMS (7 Hours)
z-Plane Specifications of Control System Design, Digital Compensator Design using Frequency Response Plots, Digital Compensator Design using Root Locus Plots, z-Plane Synthesis

Textbooks:

1. M.Gopal,“DigitalControlandStateVariableMethods4/E”,McGrawHillEducation.
2. Hemchandra Madhusudan Shertukde, "Digital Control Applications Illustrated with MATLAB" 2015, CRCPress

References:

1. B.C.Kuo,“Digital Control Systems 2/E”,Oxford University Press-NewDelhi
2. Landau Landau, Zito Landau,"Digital Control Systems: Design, Identification and Implementation,1/E", Springer-Verlag
3. V.I.George, C.P.Kurian, "DigitalControlSystems1/E", Cengage Learning
4. Kavita Singh, Rashmi Vashisth, "Digital Control System", Galgotia Publications

P3PGCC01 RESEARCH METHODOLOGY

MODULE-I:
Introduction to RM: Meaning and significance of research. Importance of scientific research in decision making. Types of research and research process. Identification of research problem and formulation of hypothesis. Research Designs.

MODULE-II:
Measurement and Data Collection. Primary data, Secondary data, Design of questionnaire ; Sampling fundamentals and sample designs. Measurement and Scaling Techniques, Data Processing.

MODULE-III:
Data Analysis – I: Hypothesis testing; Z-test, t-test, F-test, Chi-square test. Analysis of variance. Non-parametric Test – Sign Test, Run test, Krushall – Wallis test

MODULE-IV:
Data Analysis – II: Factor analysis, Multiple Regressions Analysis. Discriminant Analysis, Use of SPS Package.

Reference Books
1. Research Methodology, Chawla and Sondhi, Vikas
2 Research Methodology, Paneersevam, PHI

P3PGCC02 INTELLECTUAL PROPERTY RIGHTS

Unit 1 - Introduction
Intellectual property: meaning, nature and significance, need for intellectual property Right (IPR), IPR in India – Genesis and development, IPR in abroad, Examples:-Biotechnology Research and Intellectual Property Rights Management.
What is a patent, What can be protected by a patent, Why should I apply for a patent? Patent Law, Patentability requirements, Non-Patentable subject matters, Layout of the Patents.
Procedure for domestic and international filing of applications, Restoration, Surrender and Revocations of Patents, Rights of Patentee and Working of Patent, Licensing and Enforcing Intellectual Property.

Unit 2 – Copyrights
Copyright: meaning, scope; What is covered by copyright? How long does copyright last? Why protect copyright? Related rights, Rights covered by copyright. Ownership: Duration, Division, Transfer and Termination of Transfers.

Unit 3 – Infringement and Remedies
Literal and non-literal infringement, Role of claims, Doctrines on infringement: Equivalent doctrine, Pith and Marrow doctrine, Comparative test. Defenses: Gillette Defense, General grounds, Patents granted with conditions, Parallel import. Remedies: Civil, Administrative.

Unit 4 – State Law: Trade Secret, Contract, Misappropriation, Right of Publicity Trademarks, Trade Secret - Overview, Requirements, Misappropriation of Trade Secret, Departing Employees, Remedies, Criminal Liability, Misappropriation, Clickwrap Agreements, Idea Submissions; Right of Publicity, Federal Preemption, Review.

Books:

1. W. R. Cornish and D. Llewellyn, Intellectual Property: Patents, Copyrights, Trade Marks and Allied Rights, Sweet & Maxwell.
2. Lionel Bently and Brad Sherman, Intellectual Property Law, Oxford University Press.
3. P. Narayanan, Intellectual Property Law, Eastern Law House
4. B. L. Wadehra, Law Relating to Intellectual Property, Universal Law Publishing Co.
5. V. K. Ahuja, Law Relating to Intellectual Property Rights, LexisNexis.
6. Ajit Parulekar and Sarita D'Souza, Indian Patents Law – Legal & Business Implications;Macmillan India ltd, 2006
7. P. Narayanan; Law of Copyright and Industrial Designs; Eastern law House, Delhi, 2010.

Reference:

1. The Copyright Act, 1957
2. The Patent Act, 1970
3. The Trade Marks Act, 1999
4. The Designs Act, 2000
5. The Geographical Indication of Goods Act, 1999
6. The Protection of Plant Varieties and Farmers' Rights Act, 2001
7. The Semiconductor Integrated Circuits Layout Design Act, 2000