M.Tech.

IN

ELECTRIC VEHICLE ENGINEERING

CURRICULUM

2023 Admissions onwards

Department of Electrical Engineering
NATIONAL INSTITUTE OF TECHNOLOGY CALICUT
Kozhikode - 673601, KERALA, INDIA

The Program Educational Objectives (PEOs) of M.Tech.in Electric Vehicle Engineering

PEO1	Administer enhanced knowledge and skills in the area of Electric Vehicle Engineering so as to excel in various sectors in modern EV industry,entrepreneurial ventures or higher education and research.
PEO2	Engage in design of novel products and strategic solutions to real life problems in the areas of Electric Vehicle Engineering that are technically sound, economically feasible and socially acceptable.
PEO3	Indicate & exhibit professionalism, keep up ethics in profession and demonstrate communication skills, leadership qualities as well as willingness to work in groups.

Programme Outcomes (POs) & Programme Specific Outcomes (PSOs) of M.Tech .in Electric Vehicle Engineering

PO1	Ability to independently carry out research /investigation and development work to solve practical problems
PO2	Capacity to write and present a substantial technical report/document
PO3	Competence to demonstrate a degree of mastery over the area of Electric Vehicle Engineering, at a level higher than the requirements in the appropriate bachelor program
PO4	Ability to utilize the acquired knowledge to take up administrative challenges including the management of projects in the field of electric vehicles having multidisciplinary nature with a perspective to maintain lifelong learning process.
PO5	Willingness and ability to upkeep professional ethics and social values while carrying out the responsibilities as an electric vehicle engineer/researcher/entrepreneur in devising solutions to real life engineering problems in an independent manner.

CURRICULUM

Total credits for completing M.Tech. in Electric Vehicle Engineering is 75.

COURSE CATEGORIES AND CREDIT REQUIREMENTS:

The structure of M.Tech. programme shall have the following Course Categories:

Sl. No.	Course Category	Minimum Credits
1.	Program Core (PC)	23
2.	Program Electives (PE)	15
3.	Institute Elective (IE)	2
4.	Projects	35

The effort to be put in by the student is indicated in the tables below as follows:
L: Lecture (One unit is of 50 minute duration)
T: Tutorial (One unit is of 50 minute duration)
P: Practical (One unit is of one hour duration)
O: Outside the class effort / self-study (One unit is of one hour duration)

PROGRAMME STRUCTURE

Semester I

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	EE6601E	Sensors for EV system	3	0	-	6	3	PC
2.	EE6603E	Energy Storage Systems for Electric Vehicle	3	0	-	6	3	PC
3.	EE6605E	EV Power train: Drives and Control	3	0	-	6	3	PC
4.		Programme Elective I	3	0	-	6	3	PE
5.		Programme Elective II	3	0	-	6	3	PE
6.	EE6691E	EV Simulation Laboratory	0	0	3	3	2	PC
7.	EE6693E	Colloquium	0	0	2	1	1	PC
8.		Institute Elective	2	0	0	4	2	IE
		Total	17	0	5	38	20	--

Semester II

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	EE6612E	EV Charging Infrastructure and Analysis	3	0		6	3	PC
2.	EE6614E	Electric Vehicle System Engineering and Policy	3	0	-	6	3	PC
3.	EC6105E	Electronic Product Design	2	0	2	5	3	PC
4.		Programme Elective –III	3	0		6	3	PE
5.		Programme Elective –IV	3	0	-	6	3	PE
6.		Programme Elective –V	3	0	-	6	3	PE
7.	EE6692E	EV Hardware Laboratory	0	0	3	3	2	PC
8.	EE6694E	Project Phase I	0	0	3	3	2	
		Total	17	0	8	41	22	**--**

Semester III

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	EE7691E	Project Phase II	0	0	6	3	3	PC
2.	EE7693E	Project Phase III	0	0	30	15	15	PC
		Total	0	0	36	18	18	**--**

Semester IV

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	EE7692E	Project Phase IV	0	0	30	15	15	PC
		Total	0	0	30	15	15	**--**

List of few Electives (see note below)

S. No	Code	Title	L	T	P/S	O	C
1	ME6644E	Introduction to Vehicle Dynamics	3	0	0	6	3
2	ME6646E	Automotive Engineering For Electric Vehicles	3	0	0	6	3
3	EE6301E	Power Electronic Circuits-1	3	0	0	6	3
4	EE6312E	Power Electronic Drives	3	0	0	6	3
5	EE6411E	Industrial Drives and Control	3	0	0	6	3
6	EE6302E	Dynamics of Electrical Machines	3	0	0	6	3
7	EC 6102E	Embedded System Design	3	0	2	8	4
8	EC6104E	Electromagnetic Compatibility	4	0	0	8	4
9	EE6620E	Hybrid and Electric Vehicle	3	0	0	6	3

10	EE6401E	Industrial Internet of Things	3	0	0	6	3
11	MA 7304E	Operations Research	4	0	0	8	4
12	ME6626E	Product Design	3	0	0	6	3
13	ME6624E	Design of Electro-Mechanical Systems	3	0	0	6	3

Notes:

1. Any course from NPTEL/other recognized Universities or PG level courses offered by any of the Departments in the Institute approved by the senate of the Institute can also be credited as electives with the prior approval from the Program Coordinator.

2. List of NITC Electives offered in each semester will be announced by the Departments based on the requirement and availability of faculty.

3. Content delivery: All theory/simulation labs/Colloquium will be online. Hardware labs/evaluations/examinations will be offline at NITC.

4. Project Phase II is the summer project in the sponsored Industry or at NITC shall be completed during summer vacation and will be credited in 3rd semester.

5. Project Phase III and/or Phase IV may be carried out in industry as Internship also on appropriate approval.

M Tech in Electric Vehicle Engineering

Detailed Syllabus

EE 6601E SENSORS FOR EV SYSTEM

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Introduction:

This course is intended to empower students to design the sensors for various parameter measurement of vehicle. This course also contains a study of different types of sensors and transducers used in industry. The first module of syllabus based on the dynamic characteristics of sensors and temperature sensors for battery and motors. The second and third module mainly focused on Speed sensors, flow sensors and level sensors for industrial applications. The fourth module contains design of Nano and Micro sensor for electric vehicles and different machine learning algorithm for parameter estimation of vehicle system.

Course Outcomes:

CO1: Getting familiarized with electrical measuring systems and understand the static and dynamic performance characteristics sensors.

CO2: Understand various sensors and transducers used for electric vehicles.

CO3: Analysis of signal conditional circuits for industrial measurement systems.

CO4: Design Nano and micro sensors for EV.

CO5: Evaluate and Design machine-learning algorithm.

Review of functional blocks of measurement System-Principles of sensors and transducers – Differences Measurement and Error-Accuracy and precision- Types of errors- Systematic and random errors, propagation of errors- Classification of Transducers-Static characteristics: Accuracy, precision, resolution, sensitivity, Linearity-Dynamic characteristics - Design of Zero order and first order systems using mathematical modelling- Time response of first order system using simulation tool. Resistance Transducer: Potentiometer, strain gauge, resistance thermometer, thermistor, hotwire anemometer. Inductance Transducer: Hall effect transducer, LVDT. Capacitance Transducer: Principle, capacitive displacement transducer, practical capacitor pickups: Equibar differential pressure transducer.

Speed measurement - Encoders, Resolvers, R/D Converters, Hall current sensors and current sampling - Optical tachometer, stroboscopic tachometer -Acceleration measurement: capacitive accelerometer, angular accelerometer, velocity sensor - Density measurement: Hydrometer, ultrasonic and sonic densitometer. Viscosity measurement: Capillary viscometer, efflux cup viscometer - Humidity measurement: Dew point hydrometer, electrolytic hygrometer - pH meter - Safety measures in industrial environment. Sensor data management, linearity, data processing, MEMS, error estimation, voltage drop stack up.

Direct and indirect measurement - capacitive level sensors, optical level sensors, conductivity level sensor, vibrating sensor, float switch sensor, continuous level measurement sensor, ultrasonic sensor, microwave sensor - Analog and Digital filter design and Adaptive filter design- design of amplifiers, anti-aliasing filters. Classical parameter estimation: Cramer-Rao bound, Minimum mean squared error estimation, Minimum variance unbiased estimation, Best Linear Unbiased Estimation, Maximum Likelihood estimation, Method of Moments. Bayesian parameter estimation: Minimum mean squared error (MMSE) estimation, Maximum a posteriori estimation, Linear MMSE estimation, Sequential linear MMSE estimation, Kalman Filter.

Film sensor: Thick film sensors, Thin film sensors- Semiconductor IC Technology-Micro electro mechanical system (MEMS)- Nano electro mechanical system (NEMS). Sensor data Acquisition-Feature Extraction-Supervised Learning-Unsupervised Learning-Learning from sensor data- Performance evaluation- Comparison with deep learning- Integration point of machine learning Algorithms-Tools for machine learning. Linear regression assignment, logistic regression, model selection: practical considerations.

REFERENCES

1. Patranabis.D, “Sensors and Transducers”, 2nd Edition, Prentice Hall of India, 2021.
2. Michael Stanley and Jongmin Lee, “Sensor analysis for the Internet of Things”, 1st Edition, Morgan Claypool publishers, 2018.
3. D. Patranabis, “Principles of Industrial Instrumentation”, 4th Edition, Tata McGraw Hill, New Delhi,2017.
4. Anupama Prashar, Pratibha Bansal, “Industrial safety and Environment”, S.K. Kataria &sons, 2009.
5. R. K. Jain, “Mechanical and Industrial Measurements”, 12th Edition, Khanna publishers, 2015.
6. Randy Frank, *Understanding Smart Sensors*, Artec House Boston. London, 2000
7. Alan S. Morris and Reza Langari, 2nd ed., Measurement and Instrumentation, Theory and Application, Academic Press, 2015.
8. Bela G. Liptak, Instrument Engineers' Handbook Process Control and Optimisation, 3rd ed., vol. 2, CRC Press, 2012.
9. K. Krishnaswamy, S.Vijayachitra, “Industrial Instrumentation”, 2nd Edition, New age International Private limited, 2011.
10. *Microsensors*, Muller, R.S., Howe, R.T., Senturia, S.D., Smith, R.L., and White, R.M. [Eds.], IEEE Press, New York, NY, 1991.
11. Aurélien Géron, “Hands-On Machine Learning with Scikit-Learn, Keras, and Tensor Flow: Concepts, Tools, and Techniques to Build Intelligent Systems 2nd Edition”.

EE6603E ENERGY STORAGE SYSTEMS FOR ELECTRIC VEHICLE

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Introduction:

The detailed study about various energy storage system and their implementation for electric vehicle applications are to be addressed in this course. And also, this course is intended to empower students to evaluate the performances analysis of energy storage systems under various aspects.

Course Outcomes:

CO1: Analyse the different types of energy storage systems and their performances to electric vehicle.

CO2: Investigate the depth analysis of fuel cell technology and its integration into electric vehicle.

CO3: Design and analysis of battery parameters and its performance measures for various types of batteries.

CO4: Evaluate the battery sizing for real time driving pattern and investigate the battery testing and power management studies.

Introduction to Energy Storage Requirements in Electric Vehicles - Different types of energy storage; Mechanical: Flywheel based energy storage; Chemical: Hydrogen production and storage; Electrical: Capacitors for EV, Super Capacitor, EDLC; Electrochemical: battery, fuel cell, biological, thermal; Magnetic Energy Storage, Superconducting Energy Storage systems, Hybridization of different energy storage devices. Modelling of various emerging storage systems – Simulation case studies.

Introduction and overview of fuel cells technology: low, medium and high temperature fuel cells - Types of fuel cells, liquid and methanol types, proton exchange membrane fuel cell, solid oxide, Microbial fuel cell, Thermodynamics of fuel cells, Fuel cell modeling-simulation and case studies, system integration, Safety issues and cost expectation and life cycle analysis of fuel cells, Placement of storage systems. Battery technology, Type of battery: Lead acid, Li-ion, Li-Polymer, Ni-MH, Ni-Cd and other advanced batteries for EV's. Battery modeling-simulation and case studies.

Selection of battery cell and types, Standardized sizes and shapes pertaining to both primary and secondary batteries, Selection of Key technical terms: End of life, Depth of Discharge (DoD), State of

Charge (SoC), Cycling rate (C-rate), Study of Battery critical parameters selection (voltage of cell, Specific energy, Charge and Discharge rate, Cycle life, current density), Cell equalization problem. Thermal runaway, Battery series parallel connection and string size. Measurement, estimation and tracking of SoC. Battery mounting arrangement and installation methodology. State of health and charging efficiency and its effect on life cycle for various C-rates. Different battery management strategies, chemical properties, charge balancing, recyclability, salt based batteries, solid state batteries, battery packaging, safety considerations. Combination of super capacitor and battery – the application perspective.

Design and Applications of Energy Storage - Battery sizing and stand-alone applications, Constant current and constant voltage charging methods, Hybrid Methods, Inductive chargers, Battery power testing for various vehicles, Battery testing for urban and highway driving cycles, Battery management systems and controls, control of charge discharge cycles. Case studies. Combination of super capacitor and battery – the application perspective

REFERENCES

1. D. A. J. Rand, R. Woods, and R. M. Dell, “Batteries for Electric Vehicles,” Society of Automotive Engineers,” Warrendale PA, 2003.
2. F. A. Silva and M. P. Kazmierkowski, "Energy Storage Systems for Electric Vehicles [Book News]," in IEEE Industrial Electronics Magazine, vol. 15, no. 4, pp. 93-94, Dec. 2021.
3. A.G.Ter-Gazarian, “Energy Storage for Power Systems”, Second Edition, The Institution of Engineering and Technology (IET) Publication, UK, (ISBN – 978-1-84919-219-4), 2011.
4. Mehrdad Ehsani, Yimin Gao, and Ali Emadi, "Modern Electric, Hybrid and Fuel Cell Vehicles: Fundamentals", CRC Press, 2010.
5. Electric Power Research Institute (USA), “Electricity Energy Storage Technology Options: A White Paper Primer on Applications, Costs, and Benefits” (1020676), December 2010.
6. Paul Denholm, Erik Ela, Brendan Kirby and Michael Milligan, “The Role of Energy Storage with Renewable Electricity Generation”, National Renewable Energy Laboratory (NREL) – A National Laboratory of the U.S. Department of Energy – Technical Report NREL/ TP6A2-47187, January 2010.
7. Kim, Y., & Chang, N. (2014). Design and management of energy-efficient hybrid electrical energy storage systems. Cham, Switzerland: Springer International Publishing.
8. Rufer, Alfred. Energy storage: systems and components. CRC Press, 2017.
9. Viral, R., Tomar, A., Asija, D., Rao, U.M., & Sarwar, A. (Eds.). (2022). Smart Grids for Renewable Energy Systems, Electric Vehicles and Energy Storage Systems (1st ed.). CRC Press.

EE6605E ELECTRIC POWER TRAIN: DRIVES AND CONTROL

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Acquire knowledge about various types of power trains and various converters utilized in EV drives.

CO2: Develop capability to model drives and braking characteristics-involving load estimation, load cycle considerations, thermal aspects and motor-converter matching.

CO3: Analyse the various controllers used in DC and AC drives

CO4: Design and analyse various power converters used in Electrical Drives and their control.

Review of Conventional Vehicle: Introduction to Electric Vehicles: Electric Drive-train, Tractive effort in normal driving, Energy consumption concept of Electric Drive Trains and its Architecture-Electric Propulsion unit. Si, SiC, GaN devices based power converters - Distribution of electric power in DC-DC, AC-DC, DC-AC converters used in EV drives. Various Hybrid/EV architectures, Various switched mode DC/DC converters for EV drive. Construction and operation of speed control using acceleration pedal.

Role of power converters in Drives. DC-DC Converters, buck-boost, bidirectional DC-DC Converters, effect of parasitic elements, performance analysis, controllers design for DC-DC converters, Single Phase and Three Phase Inverter, VSI and CSI topologies, PWM Techniques- Space Vector PWM-Hysteresis Control, Comparison of PWM techniques and closed loop control of drives.

Transmission and Drive Train Characteristics-Regenerative Braking Characteristics-Driving Cycles Modelling and Analysis of Electric Vehicles Propulsion and Braking -Longitudinal Dynamics Equation of Motion.

Drive efficiency: impact of altitude, ambient temperature, gradient and motors. Different type of motors used and its comparative study. Torque vs speed, calibration of drive train based on vehicle parameters. EV design and components sizing. Electric Drive Train Overview, Systems with Linear Motion and Rotating Systems, Types of loads, Four Quadrant Operation. Induction Motor for EV power train, Variable

Voltage Variable Frequency Control - Steady State Analysis of Induction Drive, Direct & Indirect Vector Control, and Direct Torque Control.

BLDC drives-various speed control strategies – closed loop control – Autonomous control. Control strategies of regenerative braking in drives. Speed control of AC drives.
Permanent magnet synchronous machine for EV power train, Non-Salient & Salient Drives, Generic Model, Steady State Analysis, Field Oriented Control.
Switched Reluctance Machine for EV power train. Operating principles, Analysis of SRM drives and speed control.
Multi-input EV drives concepts and their operation.

References:

1. Ali Emadi, "Handbook of Automotive Power Electronics and Drives", Taylor & Francis Group, First Edition, USA, 2005.

2. Bimal K Bose; Modern Power Electronics and AC Drives & quot;, Pearson Education, second Edition, 2003.

3. David Crolla, Behrooz Mashadi, "Vehicle Powertrain Systems", January 2012, Wiley.

4. P.C. Sen, "Modern Power Electronics", Wheeler Publishing Co, Third edition, New Delhi,2008.

5. Tom Denton, 'Automotive Electrical and Electronic Systems', Routledge, Taylor and Francis Group, 5th Edition, 2017.

6. Hybrid Electric Vehicle System Modelling and Control - Wei Liu, General Motors, USA, John Wiley & Sons, Inc., 2017.

7. Hybrid Electric Vehicles – Teresa Donateo, Published by ExLi4EvA, 2017.

8. Electric and Hybrid Vehicles Power Sources, Models, Sustainability, Infrastructure and the Market Gianfranco Pistoia Consultant, Rome, Italy, Elsevier Publications, 2017.

9. R Krishnan , Electric motor drives: Modelling, Analysis, and Control, 2013.

EE6691E EV SIMULATION LABORATORY

Pre-requisites: **NIL**

L	T	P	O	C
0	0	3	3	2

Total Practical Sessions:39

Introduction:

The real time experimental study of electric vehicle by assessing the various parameters and execute the testing methodologies to evaluate the performances of power converters and battery units will be delivered. And also, by implementing the braking characteristics, the challenges of real time EV system can be investigated through experimental study.

Course Outcomes:

CO1: Real time investigation on performance analysis of EV by considering various forces acting on EV

CO2: Develop the skill to design the suitable power train for electric vehicle

CO3: Construct the simulation model to design and analyse the performances of power converters in EV applications

CO4: Investigate the performances of series parallel hybrid electric vehicle along with regenerative braking by assessing the various parameters of EV.

List of compulsory experiments:

1. Develop a simulation model to analyse the effect of Rolling Resistance on vehicle range and Performance

2. Develop a simulation model to analyze the effect of vehicle mass on vehicle range and Performance

3. Develop a simulation model to analyze the effect of Aerodynamic drag and Hill Climbing force on vehicle range and Performance

4. Simulation study and analyze the performance of speed control of Induction motor drives in EV.

5. Simulation study and analyze the performance of speed control of PMDC and BLDC motor drives in EV.

6. Simulation study of LV/High current electric motor drives with BLDC or PMSM drive.

7. Develop a simulation model to analyze Electric Motor Regenerative Braking Characteristics for different Driving Cycles.

8. Simulation study of Battery Management System in EV

9. Develop a simulation model for Series/parallel HEV to analyze the effect of changing of parameters on vehicle range and performance.

10. Simulation study of data acquisition system of EV

Desirable Experiments:

1 Case study of 2/3/4 wheeler e-vehicle/hybrid vehicle

2 Simulation study and analyze the performance of speed control of SRM/ PMSM drives in EV.

EE6693E COLLOQUIUM

Pre-requisites: **NIL**

L	T	P	O	C
0	0	2	1	1

Total Sessions: 26

Course outcomes:

CO1: Identify research papers for understanding emerging technologies in the field of EV Engineering, summarize and study. Review the effectiveness.

CO2: Identify promising new directions of various innovative technologies.

CO3: Impart skills in preparing a detailed report describing the reviewed topic.

CO4: Effectively communicate by making an oral presentation.

Course Contents:

Individual students will be asked to choose a latest topic in any field of EV Engineering-study in detail through literature review. Prepare a detailed report- state of art of the technology, methodology, applications, case studies etc and give presentation about thirty minutes. A committee (appointed by the HOD/Programme coordinator) consisting of at least three faculty members specialized in the area will assess the report and presentation and award the marks to the students and provide feedback for improvements, if necessary.

Evaluation: Based on report and oral presentation

EE6602E ELECTRIC VEHICLE CHARGING INFRASTRUCTURE AND ANALYSIS

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Introduction:

The structure and operation details of EV charging infrastructures and design, analyse and sizing the EV charging infrastructure are reported in this course. In addition, various charging methodologies are analysed in core level and design the specification of EV charger and communication protocol are addressed.

Course Outcomes:

CO1: Analyse the impact of EV charging on power grid.

CO2: Design and analyse the various charging infrastructures and their selection and sizing.

CO3: Evaluate the various charging methodologies and analyse their performances.

CO4: Design the charger specifications along with study and selection of communication protocol for various charging ports.

Introduction, EV charging options and infrastructure, energy, economic and environmental considerations, Impact of EV charging on power grid-distribution system, effect of EV charging on generation and load profile, Smart charging technologies, Identification of EV demand, EV penetration level for different scenarios, classification based on penetration level. General safety requirement for electric vehicle charging stations: IS/IEC 62305.

Types of charging stations and Charging Infrastructure, Battery Swapping Station, Move-and-charge zone. AC charging and DC charging - On board and off board charger specification - EVSE technical specification and charging time calculation - Selection and sizing of fast and slow charger (AC & DC) - AC Pile Charger, DC Pile Charger. Charging – Interoperability of chargers, impact of battery life due to chargers

Renewable Energy based Electric Vehicle Charging Station - Calculation and Selection - Components of Charging Station - Earth protection system for charging stations – Fire & safety aspects of charging stations, EV impacts on system demand: dumb charging, multiple tariff charging, smart charging, burp charging, negative pulse charging, random charging, high speed/fast charging, and different case studies of charging approach.

Selection of EVSE Communication Protocol (PLC / Ethernet / Modbus/ CAN Module) - Communication gateway - Specification of open charge point protocol (OCCP 1.6/2.0) - Bharat DC001 & AC001 Charger specification - Communication between AC charger and EV - Selection of DC charger connector GB/T, CHAdeMO, CCS-1 and CSS-2 - Communication methodology of DC fast chargers. IoT based communication supporting systems for performance measures of EVs. Recent advancements in Vehicle to Grid (V2G) and Grid to Vehicle (G2V) technologies – Case Studies on EV charging. Reliability of charging stations – predicative approach and analysing for long-term maintenance free operation. Significance of bathtub curve, reliability prediction based on working condition.

REFERENCES:

1. A. Khajepour, S. Fallah and A. Goodarzi, “Electric and Hybrid Vehicles Technologies, Modeling and Control: A Mechatronic Approach”, John Wiley & Sons Ltd, 2014.
2. Emadi, A. (Ed.), Miller, J., Ehsani, M., “Vehicular Electric Power Systems” Boca Raton, CRC Press, 2003
3. Husain, I. “Electric and Hybrid Vehicles” Boca Raton, CRC Press, 2010.
4. Larminie, James, and John Lowry, “Electric Vehicle Technology Explained” John Wiley and Sons, 2012
5. Tariq Muneer and Irene IllescasGarcía, “The automobile, In Electric Vehicles: Prospects and Challenges”, Elsevier, 2017.
6. Sheldon S. Williamson, “Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles”, Springer, 2013.
7. Alam, M. S., Pillai, R. K., & Murugesan, N. (Eds.). (2022). Developing Charging Infrastructure and Technologies for Electric Vehicles. IGI Global.

EE6604E ELECTRIC VEHICLE SYSTEM ENGINEERING AND POLICY

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

CO1: Create awareness among students about the concepts of electric vehicle system engineering.

CO2: Enable the students to investigate the various testing methodologies of EV.

CO3: Equip the students with knowledge and enable them to perform EV Modelling & Simulation.

CO4: To impart the knowledge of electric vehicle policy.

Introduction to EV technologies, Types of EV architecture, Electric vehicle and environment, Vehicle classification, Usage pattern for electric vehicles, Standardization in e-mobility, Government policies: standards and regulation, Design aerodynamics, Chassis model for battery operated vehicles BMS Design Considerations, Electromagnetic compatibility testing, Efficiency and emissions testing, On-road electric vehicles testing, Battery Electric vehicle safety and crash worthiness.

Range modelling of EV, Driving cycles. Acceleration performance parameter based testing (Aerodynamic drag, hill climbing force, total tractive effort), Constant velocity range modelling, Dynamic tests, static tests, Charge and discharge testing, Battery performance, material performance and cell performance modelling, Energy Storage Testing for Safe Electrification of Transport, Range testing based on different types of battery (Li ion and fuel cell based vehicles). Reliability index investigation on EV – Standards and specifications.

Modelling of BEV-Forward looking Model-Driver Perspective, Backward Looking Model-Drive Cycle Perspective, Modelling of Driver, Modelling of Brake Control Unit, Modelling of Vehicle Control Strategy, and Modelling of Vehicle Chassis.

Sizing of Components- Steady State Energy Balance Equation, Powertrain Dimensioning-Peak vs Continuous performance, Type of Drive cycles, Types of Control Strategy, Analysis-Performance, Range, and Consumption Prediction. Safety and security aspects of EV.

Communication standards-communication architecture for DC fast charging, communication protocols and verification procedures that support electric vehicle (EV)-grid connectivity, criteria for connecting EV to utility for AC level 1 and level 2 charging. Nature and scope of policies to stimulate widespread EV adoption and support EVCI station implementation; policy formulation and implementation at various levels of government; examples of policies and incentives for EV adoption; replacement of the gasoline tax funding source in an increasingly electrified environment.

References:

1 "Electric powertrain: energy systems, power electronics & drives for hybrid, electric & fuel cell vehicles", Goodarzi, Gordon A., Hayes, John G, Wiley 2018.
2 Advanced Electric Drives – Analysis, Modeling, Control, RiK De Doncker, Springer publications.
3 Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Fundamentals, Theory and Design, Mehradad Eshani, Yimin Gao, Ali Emadi. Second Edition, CRC Press, Taylor and Francis Group, 2010.
4 Electric and Hybrid Vehicles Design Fundamentals, Iqbal Husain, Second Edition, CRC Press, Taylor and Francis Group, 2011.
5 Electric Vehicle Technology Explained, James Larminie John Lowry, Second Edition, Wiley, 2012.
6 Introduction of Hybrid Vehicle System Modelling and Control, Wei Liu, Wiley student edition 2013.
7 Power Electronics Convertor, Applications, and Design, NED MOHAN, Third Edition, Wiley, 2002.
8 Advanced Electrical Drives, De Doncker, Rik, Pulle, Duco W.J., Veltman, Andre, First Edition, CRC Press, Taylor and Francis Group, 2011.

EE6694E PROJECT PHASE - I

Total Sessions: 39

L	T	P	O	C
0	0	3	3	2

Course Outcomes:

CO1: Develop skill sets to take up projects through identifying problem formulation, methodology and outcome for giving solutions to small industrial technical problems.

CO2: Pursue a project under a topic of interest in the area of Electric Vehicle through literature search, design, numerical computations and hardware implementation.

CO3: Train on new technologies/tools to resolve industrial problems, which is cost-effective with a scope of product development.

CO4: Through presentation/ hardware demonstration, effectively share the knowledge learned/ solutions for the identified problem and write technical report about the work for publications in peer reviewed conferences/journals.

Guidelines:

Each student should identify a challenging topic in the area of EV Engineering for the mini project and it has to be completed within one semester time span under the guide ship of any institute faculty. He/ she can have additional guides from industries. Student has to study the topic and relevant literature to identify problem based on challenges, objectives, methodology, probable outcomes and work-time flow. Based on these, he shall submit a proposal. A committee (appointed by the HOD/Programme coordinator) consisting of at least three faculty members specialized in the area and proposed guide will look through the proposal- give approval to continue or suggest modifications. Student can utilize the laboratory setups, softwares available. In addition, they can take necessary data/information from industries/other technical institutions to improve the standard of the work. There will be review meetings to assess the progress of the work during the semester. After the completion of the work, students have to give oral presentations with hardware demonstration that would be evaluated by the committee. Once the committee approves the work, student can submit a detailed report in the prescribed format and get it duly signed by the guide and attested by the HOD.

Evaluation: Based on technical contributions, hardware assembly and results, report and presentation. Appropriate weightages for interim and final evaluations.

EE6692E ELECTRIC VEHICLE HARDWARE LABORATORY

Pre-requisites: **NIL**

L	T	P	O	C
0	0	3	3	2

Total Practical Sessions: 39

Introduction:

The real time experimental study of electric vehicle by assessing the various parameters and execute the testing methodologies to evaluate the performances of power converters and battery units will be delivered. And also, by implementing the braking characteristics, the challenges of real time EV system can be investigated through experimental study.

Course Outcomes:

CO1: Develop the skill to Design and analyse the performances in motoring and braking operation of EV.

CO2: Investigate the speed tests and anti-theft detection systems.

CO3: Evaluate the performances of motor by measuring the real time parameters of electric vehicle

CO4: Evaluate the performances of power converter unit by measuring the real time parameters of electric vehicle

CO4: Investigate impact on battery performances and their challenges.

List of compulsory experiments:

1. To perform the speed control (forward and reverse) of Electric vehicle using throttle and analyse the torque production
2. Control of Electrical braking system (low brake and high brake)
3. Implementation of anti-theft detection system
4. Auto speed set and its control in Autonomous electric vehicle
5. Study of braking system in Autonomous electric vehicle
6. Measurement of temperature, battery voltage and current and display in TFT display
7. Accurate measurement of three phase current using Hall effect sensors
8. Measurement of DC-link current, voltage and BMS data of EV
9. Measure accurate level of battery charging and its indication
10. Balancing of Cells-Active and Passive

Desirable Experiments:

1. Case study on thermal runaway of battery, motor and power trains.
2. Sending the EV sensor data sets into IoT cloud

SEMESTER 3

E7691E PROJECT PHASE - II

(to be done as summer project)

Pre-requisite: **NIL**

L	T	P	O	C
0	0	6	3	3

Total period: Summer Vacation

Course Outcomes:

CO1: Develop comprehensive solution to issues identified in previous semester work and meet the requirements as stated in project proposal

CO2: Compile the results of the detailed analytical studies conducted and interpret the results for application to the instrumentation and control system.

CO3: Summarize the results and effectively communicate the research contributions and publish in reputed Journals /Conference or file a patent/copyright.

Guidelines:

Each student should identify a challenging topic in the area of EV Engineering, which can be done as a project with in one or two semester(s) time span under the guide ship of any faculty from the Institute. He/she can have additional guides from industries also. Student has to study the topic and relevant literature to identify problem based on challenges, objectives, methodology, probable outcomes and work-time flow. Based on these, he shall submit a proposal. The problem shall be of sufficient size and challenging to come with innovative solutions. A committee (appointed by the HOD/ Programme coordinator) consisting of at least three faculty members specialized in the area and proposed guide will look through the proposal- give approval to continue or suggest modifications. Student can utilize the laboratory setups, software's available. In addition, they can take necessary data/information from industries/other technical institutions to improve the standard of the work. There will be review meetings to assess the progress of the work during the semester. If he/she is doing the project based on the industrial problem, as a part of the internship in a reputed industry, there will be a guide from the industry also.

After the completion of the work, students have to give oral presentations with hardware demonstration that would be evaluated by the committee. Once the committee approves the work, student can submit a detailed report in the prescribed format and get it duly signed by the guide and attested by the HOD.

Evaluation: Based on technical contributions, hardware assembly and results, report, presentation and publications. Appropriate weightages for interim and final evaluations.

EE7692E PROJECT PHASE - III

Pre-requisite: **NIL**

L	T	P	O	C
0	0	30	15	15

Total period: one semester

Course Outcomes:

CO1: Develop comprehensive solution to issues identified in previous semester work and meet the requirements as stated in project proposal

CO2: Compile the results of the detailed analytical studies conducted and interpret the results for application to the instrumentation and control system.

CO3: Summarize the results and effectively communicate the research contributions and publish in reputed Journals /Conference or file a patent/copyright.

Guidelines:

If the problem identified in second semester is sufficiently large and still more work is required to complete, same project can be extended to third semester as Project – Part III on approval by the evaluation committee.

Otherwise, the followings are guidelines:

Each student should identify a challenging topic in the area of EV Engineering, which can be done as a project with in one semester time span under the guide ship of any faculty from the Institute. He/she can have additional guides from industries also. Student has to study the topic and relevant literature to identify problem based on challenges, objectives, methodology, probable outcomes and work-time flow. Based on these, he shall submit a proposal. The problem shall be of sufficient size and challenging to come with innovative solutions. A committee (appointed by the HOD/Programme coordinator) consisting of at least three faculty members specialized in the area and proposed guide will look through the proposal- give approval to continue or suggest modifications. Student can utilize the laboratory setups, softwares available. In addition, they can take necessary data/information from industries/other technical institutions to improve the standard of the work. There will be review meetings to assess the progress of the work during the semester. If he/she is doing the project based on the industrial problem, as a part of the internship in a reputed industry, there will be a guide from the industry also.

After the completion of the work, students have to give oral presentations with hardware demonstration that would be evaluated by the committee. Once the committee approves the work, student can submit a detailed report in the prescribed format and get it duly signed by the guide and attested by the HOD.

Evaluation: Based on technical contributions, hardware assembly and results, report, presentation and patent/publications. Appropriate weightages for interim and final evaluations.

EE7692E PROJECT PHASE - IV

Pre-requisite: **NIL**

L	T	P	O	C
0	0	30	15	15

Total period: one semester

Course Outcomes:

CO1: Develop comprehensive solution to issues identified in previous semester work and meet the requirements as stated in project proposal

CO2: Compile the results of the detailed analytical studies conducted and interpret the results for application to the instrumentation and control system.

CO3: Summarize the results and effectively communicate the research contributions and publish in reputed Journals /Conference or file a patent/copyright.

Guidelines:

If the problem identified in third semester is sufficiently large and still more work is required to complete, same project can be extended to fourth semester as Project – Part IV, on approval by the evaluation committee.

Otherwise, the followings are guidelines:

Each student should identify a challenging topic in the area of EV Engineering, which can be done as a project with in one semester time span under the guide ship of any faculty from the Institute. He/she can have additional guides from industries also. Student has to study the topic and relevant literature to identify problem based on challenges, objectives, methodology, probable outcomes and work-time flow. Based on these, he shall submit a proposal. The problem shall be of sufficient size and challenging to come with innovative solutions. A committee (appointed by the HOD/Programme coordinator) consisting of at least three faculty members specialized in the area and proposed guide will look through the proposal- give approval to continue or suggest modifications. Student can utilize the laboratory setups, softwares available. In addition, they can take necessary data/information from industries/other technical institutions to improve the standard of the work. There will be review meetings to assess the progress of the work during the semester. If he/she is doing the project based on the industrial problem, as a part of the internship in a reputed industry, there will be a guide from the industry also.

After the completion of the work, students have to give oral presentations with hardware demonstration that would be evaluated by the committee. Once the committee approves the work, student can submit a detailed report in the prescribed format and get it duly signed by the guide and attested by the HOD.

Evaluation: Based on technical contributions, hardware assembly and results, report, presentation and patent/publications. Appropriate weightages for interim and final evaluations.

ME6644E INTRODUCTION TO VEHICLE DYNAMICS

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Introduction:

This course is intended to empower students to evaluate the various dynamics loads acting of a vehicle and to design or select the vehicle systems to suite the market requirements. The course also contains a study of various vehicles systems presently used in the conventional automobiles. A qualitative study of various factors affecting the ride and handling of the vehicle is also covered in the syllabus. The first two modules of the syllabus are primarily based on the dynamics of 4 wheeled vehicles while the third modules of the syllabus is dedicated to the topics related to the dynamics of motorcycles.

Pedagogical approach

The course is designed primarily for a lecture based course delivery. Case studies will be discussed at the relevant occasions to empower the students understand the practical issues. Assignments will be included in the pedagogy, to familiarize the students with the broader topics in the related area. The evaluation of the course will be through a series of tests, assignments and case studies.

Course Outcomes:

1. Describe the various static and dynamic forces acting on a vehicle
2. Evaluate the effect of various vehicle parameters on the ride and handling of the vehicle.
3. Evaluate the various factors affecting the dynamics of two wheelers.

Basics of engineering mechanics and dynamics: Free body diagrams- Newton's laws of motion- law of friction- Rolling friction

Static loads in vehicle: Axle loads in stationary vehicles- Axle loads on gradients

Dynamics Loads in acceleration: Acceleration loads-maximum possible acceleration-traction limited acceleration- Effect of front wheel drive/ rear wheel drive/ all-wheel drive systems.

Dynamic loads during braking: Braking performance- brake distribution between front and rear wheels-wheel lock up- electronics to prevent wheel lock up- Antilock braking systems(ABS)- Electronic Brake Distributions(EBD)

Miscellaneous Loads: Aerodynamic loads- Riding resistance, Power required to cruise at constant speeds.

Suspension systems: Basic suspension systems- independent suspensions-vehicle modeling with single degree of freedom model -Quarter car model - Effect of suspension stiffness on ride and handling. Advanced systems to improve ride and handling- progressive springs and dampers- active and semi active suspension systems

Steering- steering geometry- Caster, Camber, Toe-in, toe-out steady state cornering- understeer and oversteer- all wheel steering systems- study of various steering systems used in modern automobiles

Wheels and tires: - Basic tire nomenclature- Effect of unsprung mass- Effect of moment of inertia, Roll over analysis

Motorcycle dynamics: Modeling of two wheelers- loads on wheels- forces acting on motor cycle

Front wheel/steering Geometry- caster angle, Offset, Trail, Effect of steering geometry on straight-line stability and handling.

Motorcycle suspension: Types-telescopic, upside down forks, relative advantages and disadvantages,

Vehicle Frames: Types- single cradle, double cradle, perimeter frame, Trellis frame, monocoque construction- Relative advantages and disadvantages

References:

1. T. D. Gillespie, Fundamentals of Vehicle Dynamics. Society of Automotive Engineers, 1992.
2. J. Y. Wong, Theory of Ground Vehicles, 4th ed. John Wiley and Sons, 2008.
3. H. Pacejka, Tyre and Vehicle Dynamics, 3rd ed. Butterworth-Heinemann, 2012.
4. M. Blundell and D. Harty, The Multi body Systems Approach to Vehicle Dynamics, 1st ed. Butterworth-Heinemann, 2004.
5. Vittore Cossalter, Motor Cycle Dynamics, Lulu.Com; 2nd ed. Edition, 2006

ME6644E INTRODUCTION TO VEHICLE DYNAMICS

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Basics of Engineering Mechanics and Dynamics: Free body diagrams- Newton's laws of motion- law of friction- Rolling friction Static loads in vehicle, Dynamic loads during acceleration-traction limited acceleration, Dynamic loads during braking, wheel lock up- electronics to prevent wheel lock, Aerodynamic loads, Riding resistance, Power required to cruise at constant speeds. Suspension systems-vehicle modelling, effect of suspension stiffness on ride and handling. Study of advanced systems to improve ride and handling, steering geometry, Steady state cornering- understeer and oversteer-study of various steering systems used in modern automobiles, Wheels and tires: Basic tire nomenclature, Effect of unsprung mass, effect of moment of inertia, roll over analysis Motorcycle dynamics: Modeling of two wheelers, Front wheel steering geometry, Effect of steering geometry on straight line stability and handling. Motorcycle suspension: types, advantages and disadvantages, Vehicle frames: Types-advantages and disadvantages

ME 6646E AUTOMOTIVE ENGINEERING FOR ELECTRIC VEHICLES

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Introduction:
The various systems of electric vehicles are discussed in this course. The course content is tailor-made to understand the subtle difference between the various systems used in the conventional vehicles and

electric vehicles. The course is intended to cover steering, braking, transmission, and suspension systems of electric vehicles. The course content also includes details of batteries, battery cooling systems etc. A brief introduction about the various standards used in the charging of the EVs, various government regulations related with the EVs are also presented in the course.

Course Outcomes:

CO1: Classify electric vehicles based on the configuration level.

CO2: Analyse the suspension and transmission systems associated with EVs

CO3: Analyse the braking system and steering systems of EVs

CO4: Evaluate the factors affecting the performance of batteries.

Conventional vehicle systems and configurations: Engine components and systems, four stroke engines, engine performance, air pollution, emission norms.

Overview of Electric Vehicles: History of Electric vehicles, Basic construction of Electric vehicles, Electric vehicles vs Conventional vehicles. Battery electric vehicles (BEVs), hybrid electric vehicle (HEV), types of hybrid vehicles, plug-in hybrid electric vehicle (PHEV), fuel cell electric vehicle (FCEV): Electric vehicles standards and regulations

Chassis and Body: Frames – Conventional, Semi-Integral, Integral type., Chassis - Ladder frame, Backbone, Monocoque, Tubular chassis. Advantages and disadvantages.

Suspension system: Springs: coil springs, leaf springs, torsion bars.

Dampers**:** Hydraulic dampers, Nitrox dampers, Telescopic and USD suspensions, MR and ER dampers.

Types of suspension systems: rigid axle and independent suspensions, air suspension systems, electronic suspension systems, electromagnetic suspension, active and passive suspension systems.

Wheels and tires: Types of wheels, Front /rear wheel drive configurations - Four/All-wheel drive configurations.

Transmission system: Power train configurations and components, hub motor direct drive configuration, centrally mounted configuration, differential- classification and types.

Braking systems: Drum brakes, disc brakes, hydraulic brakes, power-assisted brake, air brakes, electric brakes, anti-lock braking system (ABS), electronic brake force distribution system (EBD), regenerative braking, brake assist system.

Supplementary restraint system, air bags, pyrotechnic inflator, air bag control unit.

Steering system: Steering mechanism, steering geometry, steering gears, power-assisted steering - hydraulic power steering (HPS), electric power hydraulic steering (EPHS), electric power steering (EPS).

Electric motors & batteries: Types of motors, Types of batteries, constructional details, thermal management of batteries, vent management system, Battery life analysis, Battery performance degradation modelling and analysis.

References:

1.H. Heisler, Advanced Vehicle Technology, 2nd ed. Butterworth–Heinemann, 2002.

2.M Ehsani, Y Gao, L K Ebrahimi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, 3rd Edition, Taylor and Francis, 2018.

3.Tom Denton, Electric and Hybrid Vehicles ,2nd ed., Routledge, 2020

4.W. H. Crouse and D. L. Anglin, Automotive Transmission and Power Trains construction, 10th ed. McGraw Hill, 2008.

5.W. H. Crouse and D. L. Anglin, Automotive mechanics, 10th ed. Tata McGraw-Hill, 2004.

6.K. Newton, W. Steeds, and T. K. Garret, Motor Vehicle, 13th ed. Butterworth-Heinemann, 2004.

7.M Matschinsky, Road Vehicle Suspensions, Wiley, ISBN: 978-1-860- 58202-8, 1997.

8.J Jiang, C Zhang, Fundamentals and Applications of Lithium-ion Batteries in Electric Drive Vehicles, Wiley, 2015

9. V. Sajith and S. Thomas, Internal Combustion Engines, 1st ed. Oxford University Press, 2017.

EE6421E HYBRID AND ELECTRIC VEHICLES

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Explain performance characteristic and model dynamics of hybrid and electric vehicles
CO2:Analyse the architecture of drive trains and electric propulsion units of electric and hybrid vehicles
CO3: Analyse various energy storage devices used in hybrid and electric vehicles and select the electric drive system
CO4: Explore energy management strategies used in hybrid and electric vehicles

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies - Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.

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

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Analysis of various energy storage devices – Battery, Fuel Cell, Super, Flywheel - Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor and power electronics, selecting the energy storage technology, Communications, supporting subsystems

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification, comparison and implementation issues of energy management strategies. Case Studies: Design of a Hybrid Electric Vehicle (HEV) and Battery Electric Vehicle (BEV).

References:

1. I. Husain, Electric and Hybrid Electric Vehicles, CRC Press, 2003

2. M. Ehsani, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2005

3. A. E. Fuhs, Hybrid Vehicles and the Future of Personal Transportation, CRC Press, 2009

4. C. C. Chan and K. T. Chau, Modern Electric Vehicle Technology, Oxford Science Publication, 2001 Industrial Power and Automation, Department of Electrical Engineering, NIT Calicut - 673601 93

5. G. Lechner and H. Naunheimer, Automotive Transmissions: Fundamentals, Selection, Design and Application, Springer, 1999

6. Gianfranco, Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure and the Market, Pistoia Consultant, Rome, Italy, 2010

7. M. H. Rashid, Power Electronics: Circuits, Devices and Applications, 3rd ed., Pearson, 2004 8. V. R. Moorthi, Power Electronics: Devices, Circuits and Industrial Applications, Oxford University Press, 2007

9. R. Krishnan, Electric motor drives: modeling, analysis, and control, Prentice Hall, 2001

10.P. C. Krause, O. Wasynczuk, S. D. Sudhoff, Analysis of electric machinery, IEEE Press, 1995

11.L. Guzella, A. Sciarretta, Vehicle Propulsion Systems, Springer, 2007

EC6105E ELECTRONIC PRODUCT DESIGN

Pre-requisites: **NIL**

L	T	P	O	C
2	0	2	5	3

Total Lecture/Practical Sessions: 26L+26P

Course Outcomes:

CO1: Summarize the life cycle of an electronic product and its design process

CO2: Evaluate the reliability of an electronic product

CO3: Create the industrial design of an electronic product considering aesthetics, ergonomics and thermal design aspects

CO4: Build prototype of an electronic product undergoing different stages of product development life cycle.

Lecture (26 Sessions):

Life cycle of electronic products, Product planning- Customer need identification, feasibility study, specifications etc. Design and Development Process, Technical drawings, Circuit diagrams, Computer aided design

Reliability of Electronic Products: Calculation principles – Terminologies, parameters, Mathematical modelling, Failure of electronic components and systems, Reliability analysis
Design for Manufacturing, Design for Testing, Design for Environment

Industrial Design, Aesthetics, Ergonomics,
Thermal Design – Power dissipation in electronic components, temperatures of components and systems, Electrical and thermal network methods of calculations, Heat transfer, Methods to increase heat transfer

Practical (26 Sessions)

The students need to implement the prototype model of an electronic product undergoing different stages of product development life cycle, which include:

- Requirements/market study/feasibility study
- Finalizing the Specifications
- Mechanical design
- Ergonomics and Aesthetics
- Hardware Design
    - Component selection

    - Schematic Entry
    - Layout Design
    - PCB manufacturing and assembly
- Mechanical Assembly
- Software Design
- Testing.

In this process students will be familiarised with different tools and machines like Shop bot, 3D printer, Laser cutter, PCB fabrication machine & soldering tools.

References:

1. Jens Lienig, Hans Bruemmer, Fundamentals of Electronic Systems Design, Springer, 2017
2. Karl T. Ulrich , Steven D. Eppinger, Product Design and Development, Mc Graw Hill, 2016
3. V.B. Baru R.G.Kaduskar, Electronic Product Design, Wiley India 2011
4. Tony Ward and James Angus, Electronic Product Design, Chapman &Hall 1996