METHODIST COLLEGE OF ENGINEERING & TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

B.E. MINOR PROGRAM –ELECTRIC VEHICLES
SCHEME OF INSTRUCTION

S. No.	Course Code	Course Name	L	P	T	Credits	Study Semester
1.	EV01EE	Fundamentals of Electric and Hybrid Electric Vehicles	**3**	**0**	**0**	**3**	**V**
2.	EV02EE	EV Batteries and Chargers	**3**	**0**	**0**	**3**	**V**
3.	EV03EE	EV Motors and Power Converters	**3**	**0**	**0**	**3**	**VI**
4.	EV04EE	EV Simulation Lab	**0**	**4**	**0**	**2**	**VI**
5.	EV05EE	Super Capacitor and Fuel Cell Technology	**3**	**0**	**0**	**3**	**VII**
6.	EV06EE	Technical Seminar	**0**	**2**	**0**	**1**	**VII**
7.	EV07EE	Project in Electric Vehicle Technology	**0**	**6**	**0**	**3**	**VII**
Total Credits						**18**	

L- Lecture, P-Practical , T-Tutorial

DETAILED SYLLABUS
B.E. Minor – Electric Vehicles

Course code	Course Title	Core/Elective					
EV01EE	Fundamentals of Electric and Hybrid Electric Vehicles	Core					
		L	T	P/D	Credits	CIE	SEE
		3	0	0	3	40	60

Prerequisites: Pre-Requisites: Mathematics and Elements of Electrical and Electronics Engineering or equivalent subject

Course Objectives :The objective of this course is to make the student

1. Understand the Electric Vehicle Technology
2. Know the various components in EV/HEV
3. To identify the drive trains in EV/HEV

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

1. Explain the working and types of EV and HEV
2. List the components of EV and HEV
3. Analyze the drive trains for Electric and Hybrid electric vehicles.
4. Explain the Power electronics and sensors in electric vehicles.
5. Design the power rating for EV/HEV

UNIT–I: Introduction to Electric Vehicles: Past, Present & Future of EV, Current Major Issues, Recent Development Trends, EV Concept, Key EV Technology, State-of-the Art EVs & HEVs, Comparison of EV Vs IC Engine vehicle.

UNIT-II: EV System: EV Configuration: Fixed & variable gearing, single & multiple motor drive, In-wheel drives , EV Parameters: Weight, size, force, energy & performance parameters. Understanding electric vehicle components, Basic EV components and architecture, Autonomy and vehicle computing needs.

UNIT-III: Electric Drive Trains (EDT) – Series HEDT (Electrical Coupling) – Power Rating Design, Peak Power Source (PPS); Parallel HEDT (Mechanical Coupling) – Torque Coupling and Speed Coupling.

UNIT–IV: Power Electronics and Sensor-less control in EV: Basic Electronics Devices – Diodes, Thyristors, BJTs, MOSFETs, IGBTs, Convertors, Inverters. Safety – Risks and Guidance, Precautions, High Voltage safety, Hazard management. Sensors - Autonomous EV cars.

UNIT–V: **Hybrid Electric Vehicles** – Classification – Micro, Mild, Full, Plug-in, EV. Layout and Architecture – Series, Parallel and Series-Parallel Hybrid, Propulsion systems and components. Regenerative Braking, Economy, Vibration and Noise reduction.

TEXT BOOKS:

1. Jack Erjavec and Jeff Arias, "Hybrid, Electric and Fuel Cell Vehicles", Cengage Learning, 2012.
2. Mehrdad Ehsani, Yimin Gao, sebastien E. Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2009.

REFERENCES/ SUGGESTED READING:

3. Hybrid Electric Vehicle System Modeling and Control - Wei Liu, General Motors, USA, John Wiley & Sons, Inc., 2017.
4. Hybrid Electric Vehicles – Teresa Donateo, Published by ExLi4EvA, 2017.
5. Jack Erjavec and Jeff Arias, "Alternative Fuel Technology – Electric, Hybrid and Fuel Cell Vehicles", Cengage Learning Pvt. Ltd., New Delhi, 2007.

Course code	Course Title	Core/Elective					
EV02EE	EV Batteries and Chargers	Core					
		L	T	P/D	Credits	CIE	SEE
		3	0	0	3	40	60

Prerequisites: Basics of Electrical Engineering (or equivalent subject)

Course Objectives :The objective of this course is to make the student

1. Aware of the battery parameters
2. Understand the different types of batteries
3. Understand the charging infrastructure and charging methods

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

1. Elaborate various technical parameters of batteries.
2. Distinguish between various types of batteries used for EV applications.
3. Understand the charging infrastructure
4. List charging methods for EV
5. Develop a battery charger for an EV.

UNIT I: Battery parameters : 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.

UNIT II: EV Batteries: 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.

UNIT III: Sodium, Lithium and Metal air batteries: 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.

UNIT IV: Charging Infrastructure : Domestic Charging Infrastructure, Public Charging Infrastructure, Normal Charging Station, Occasional Charging Station, Fast Charging Station, Battery Swapping Station, Move-and-charge zone.

UNIT V: EV Charging: 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.

TEXT BOOKS:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

REFERENCES/ SUGGESTED READING:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
2. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001.

Course code	Course Title	Core/Elective					
EV03EE	Super Capacitor and Fuel Cell Technology	Core					
		L	T	P/D	Credits	CIE	SEE
		3	0	0	3	40	60

Prerequisites: Energy storage system of Electrical Engineering (or equivalent subject)

Course Objectives :The objective of this course is to make the student

1. Gain knowledge of different power sources of EV
2. Understand the characteristics , types of Fuel cells and their working
3. Know about different types of super capacitors and their working

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

1: Apply fundamentals of electrochemistry, thermodynamics, fluid mechanics, and heat and mass transfer to design different components of fuel cells and fuel cell systems.
2: Describing the components, processes and characterization tools in super capacitor.
3: Understand and identify different routes for hydrogen production and its storage.
4: Analyze and simulate the performance of different type of fuel cells.
5: Estimate and calculate various losses in fuel cells and propose corrective measures to reduce it.

UNIT – I: Fundamentals of Electrochemical Super capacitors and Fuel cells: Introduction, Technologies & Types, Obstacles. Operation principles, performance characteristics of super capacitors and Fuel cells, Fuel and Oxidation Consumption.

UNIT-II : Super Capacitors: Electrode and electrolyte interfaces and their capacitances, Charge-Discharge characteristics, Energy/power density, cycling and performance characteristics, difference between battery and super capacitors, Introduction to Hybrid electrochemical super capacitors.

UNIT–III: Li-Ion-Based Hybrid Super capacitors in Organic Medium: Voltage Limitation of Conventional EDLCs ,Hybrid Capacitor Systems ,Lithium-Ion Capacitor(LIC) ,Nano hybrid Capacitor (NHC), Material Design for NHC

Super capacitor Module Sizing: Super capacitor Properties, Performances, Energetic Performance and Discharging at Constant Load Power, Current, and efficiency.

UNIT–IV: Fuel Cells: Proton exchange membrane fuel cell solid oxide, hydrogen fuel cells – thermodynamics and electrochemical kinetics of fuel cells. Fuel cells for automotive applications – technology advances in fuel cell vehicle systems.

UNIT-V: Fuels for Fuel Cells: Hydrogen, methane, methanol – Sources and preparation, reformation processes for hydrogen – clean up and storage of the fuels – use in cells, advantages and disadvantages of using hydrogen as fuel.

TEXT BOOKS:

1. Supercapacitors-materials-systems-and-applications_compress-2013 Wiley-VCH Verlag GmbH & Co. KGaA, Boschstr. 12, 69469 Weinheim, Germany.
2. Fuel Cells for automotive applications – professional engineering publishing UK. ISBN 1- 86058 4233, 2004.

REFERENCES/ SUGGESTED READING:

1. Fuel Cell Technology Handbook SAE International Gregor Hoogers CRC Press ISBN 0-8493-0877-1-2003.
2. A.Yu, V. Chabot, and J. Zhang, Electrochemical Supercapacitors for Energy Storage and Delivery Fundamentals And Applications, Taylor & Francis Group, 2013.

Course code	Course Title	Core/Elective					
EV04EE	EV Motors & Power Converters	Core					
		L	T	P/D	Credits	CIE	SEE
		3	0	0	3	40	60

Prerequisites : Elements of Electrical and Electronics Engineering(or Equivalent Subject)

Course Objectives : The objectives of this course is to

1. Gain knowledge on power requirement of EV
2. Know the performance of various motors for EVs
3. Understand the converters in EVs

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

1. Calculate the power required for EV
2. Analyze the Electric motors used for EV
3. Analyze the converters for EV
4. Understand the motor control for EV operation
5. Analyze the braking operation in EV

UNIT–I: Vehicle Power: Vehicle Power requirement calculations: Rolling Resistance, air drag, hill climbing ,acceleration forces.

UNIT II: EV Motors Characteristics and DC motors: Requirement of EV motors, Comparison of EV motors, Basics of DC Motor, Torque speed characteristics, DC Motor dynamics, Field Weakening Control, Four quadrant operation.

UNIT III: Converters: Understanding Power Electronics, basic DC converter circuit, power devices and switching losses.

UNIT-III: AC Motors: Rotating Magnetic Field, Principle of operation of Induction motor, PMSM, PMBLDC, SRM and Speed-Torque characteristics.

UNIT IV: **Motor Control:** Power Electronic Control of PMSM, SRM and PMBLDC and Induction motor.

UNIT 5: Braking: Braking requirements of vehicle, methods of braking of DC motor and Induction Motor , regenerative braking and dynamic braking , coordinating electrical and mechanical brakes, braking control strategies.

TEXT BOOKS:

1. C. Mi, M. A. Masrur and D. W. Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", John Wiley & Sons, 2011.
2. S. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies", Springer, 2015.
3. Fundamentals of Electrical Drives , G.K Dubey, Narosa Publications
4. **B. K. Bose**, "Modern Power Electronics and AC **Drives**," Prentice Hall,2002.
5. Power Electronics: Circuits, Devices, and Applications' by M. H. Rashid, Pearson Education India, 2014.
6. Power Electronics: Converters, Applications and Design by N. Mohan and T.M. Undeland, John Wiley& Sons, 2007.

REFERENCES/ SUGGESTED READING:

1. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", CRC Press, 2004.
2. T. Denton, "Electric and Hybrid Vehicles", Routledge, 2016.

Course Code	Course Title	Core/Elective					
EV05EE	EV Simulation Lab	Core					
		L	T	P/D	Credits	CIE	SEE
		0	0	2	1	40	60

Pre-Requisites: Mathematics, computer knowledge, fundamentals of EV and HEV

Course Objectives: The objectives of this course is to impart knowledge of

1. To understand modelling of EV/HEV
2. To gain thorough knowledge about Simulation of EV/HEV.
3. To understand the performance of EV/HEV

Course Outcomes: Upon completion of this course, students should be able to

1. know the software programming or blocks
2. Apply the equations for modelling the EV
3. Apply the knowledge for Modelling of the HEV
4. Demonstrate the simulation of EV and HEV
5. Compare the performance of EV and HEV

LIST OF EXPERIMENTS

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1. Mathematical modelling of Electric Bicycle
2. Mathematical modelling of Electric Tricycle
3. Mathematical modelling of Electric Car
4. Simulation of 2 wheeler Electric Vehicle
5. Simulation of 4 wheeler Electric Vehicle
6. Mathematical model of Series HEV power train
7. Simulation of Series HEV power train
8. Simulation of Hybrid Electric Vehicle
9. Simulation of EV with Fuel cell and super capacitors
10. Design of a Hybrid Electric Vehicle (HEV)
11. Design of a Battery Electric Vehicle (BEV)

Simulation can be done by any software whichever is feasible.

NOTE:ATLEAST 10 EXPERIMENTS SHOULD BE CONDUCTED

SUGGESTEDREADING:

1. James Larminie Oxford Brookes University, Oxford, UK John Lowry Acenti Designs Ltd., UK, Electric Vehicle Technology Explained
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
3. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

Course Code	Course Title	Core/Elective					
EV06EE	Technical Seminar	Core					
		L	T	P/D	Credits	CIE	SEE
		0	0	2	1	50	-

Pre requisites : Knowledge EV Technology

Course Objectives: The objectives of this course is

1. To encourage the students to study advanced engineering developments.
2. To prepare and present technical reports.
3. To encourage the students to use various teaching aids such as overhead projectors, power point presentation and demonstrative models.

Course Outcomes: After Completion of the course the student will be able to

1. Review, prepare and present technological developments.
2. Enhance communication skills
3. Enhance presentation skills
4. Improve the behaviour skills and ethics
5. Face the placement interviews.

Method of Evaluation:

During the seminar session, each student is expected to prepare and present a topic on current trends in Electric Vehicle Technology (25 Marks), for a duration of about 30 minutes.

In a session of two periods per week, all students are expected to present during the seminar.

Each student is expected to present atleast twice during the semester and the student is evaluated based on that.

At the end of the semester, he / she shall submit a report on his / her topic of seminar (for 25 Marks).A Faculty guide is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance also.

Evaluation is 100% internal.

Course Code	Course Title	Core/Elective					
EV07EE	Project in Electric Vehicle Technology	Core					
		L	T	P/D	Credits	CIE	SEE
		0	0	6	3	50	100

Course Objectives :

1. The student(s) shall explore the technological needs of society.
2. The student(s) shall understand the technological problems of society.

Course Outcomes: After Completion of the course the student will be able to

1. Provide a solution to the technological problems of society.
2. Suggest technological changes which suits current needs of society.
3. Explain new technologies available for problems of the society
4. Enhance communication and presentation skills
5. Improve leadership qualities and presentation skills.

Preamble:

There is lot of scientific and technological changes in the nation during last few decades in almost all the sectors. The state and central governments are introducing many schemes to all classes of people of the nation to increase the productivity in various sectors. India is a rural centric nation and the fruits of the scientific inventions and new technology shall be shared among all remote corners of the nation. With this aim, a socially relevant project is newly introduced in the curriculum with an objective of taking up the projects relevant to the societal needs.

General guidelines:

- A socially relevant project shall be a community service based project and it shall be innovative.
- A student has to pursue the socially relevant project to solve real life and pressing problems of society.
- The pursued socially relevant projects shall contribute to national development goals and priorities.
- Socially relevant project can be carried out by an individual student or by a team of maximum five (05) of the department.
- The student(s) shall visit the society (Villages/Hospitals/Social Service Organizations etc.) to identify the problem, conduct literature survey, and provide a feasible solution through fabricated models.
- The socially relevant project selected shall be in the broad area of concerned discipline of course. Preference shall be given to rural societal problems.
- Each team shall work under the supervision of a faculty member of the concerned department.
- The attendance shall be maintained by the respective supervisor.
- The developed solutions will be assessed by the Department and shall be evaluated for 40 Marks.
- Additional 10 Marks will be awarded for the outcome based (Patents, Journal Publications, Conference Proceedings, Technical Seminar Presentations, Design Registrations, etc.) Projects.
- External examination by outside expert for 100 marks.