VII Semester

Open Elective **21CHE753**

ENERGY STORAGE SYSTEM FOR ELECTRICAL VEHICLES

Course Code	21CHE753	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

CLO 1	Understand the basic history of electric vehicles.
CLO 2	Discuss the various energy storage systems
CLO 3	Analyze the battery characteristics & parameters
CLO 4	Enlighten the battery management system
CLO 5	Apply the knowledge battery testing, disposal & recycling to avoid environmental pollution for the betterment of society

Pedagogy (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

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1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Show Video/animation films to convince abstract concepts.
4. Encourage collaborative (Group Learning) Learning in the class
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.

Module-1 - Electric vehicle Mechanism - 08 hours

Basics of vehicle mechanisms, history of electric vehicles (EV) and hybrid electric vehicles (HEV), need for and Importance of EV and HEV, Power/Energy supply requirements.

Pedagogy	**Chalk and talk/power point presentation: Basics of vehicle mechanisms, history of electric vehicles (EV) and hybrid electric vehicles (HEV)** **Videos/Learning material:** Need for and Importance of EV and HEV, Power/Energy supply requirements. **Self-study:** Current-Voltage characteristics.

Module2 -Betteries- 08 hours

Batteries: Lead Acid Battery, Nickel based batteries, Sodium based batteries, Lithium based batteries – Li-ion & Li-poly, Metal Air Battery, Zine Chloride battery; Ultra capacitors; Flywheel Energy Storage System; Hydraulic Energy Storage System; Comparison of different Energy Storage System.

Pedagogy	**Chalk and talk/power point presentation**: Batteries: Lead Acid Battery, Nickel based batteries, Sodium based batteries, Lithium based batteries – Li-ion & Li-poly, Metal Air Battery, Zine Chloride battery. **Videos/Learning material**: Ultra capacitors; Flywheel Energy Storage System; Hydraulic Energy Storage System **Self-study:** Super capacitors and their applications.

Module3 - Cells and Batteries- 08 hours

Cells and Batteries- conversion of chemical energy to electrical energy- Battery Specifications: Variables to characterize battery operating conditions and Specifications to characterize battery nominal and maximum characteristics; Efficiency of batteries; Electrical parameters Heat generation- Battery design- Performance criteria for Electric vehicles batteries- Vehicle propulsion factors- Power and energy requirements of batteries- Meeting battery performance criteria- setting new targets for battery performance.

Pedagogy	**Chalk and talk/power point presentation**: Battery Specifications: Variables to characterize battery operating conditions and Specifications to characterize battery nominal and maximum characteristics; Efficiency of batteries. **Videos/Learning material**: Battery design- Performance criteria for Electric vehicles batteries- Vehicle propulsion factors- Power and energy requirements of batteries- Meeting battery performance criteria. **Self-study:** Sodium-ion batteries.

Module-4 Batteries for Electric Vehicles- 08 hours

Selection of battery for EVs & HEVs, Traction Battery Pack design, Requirement of Battery Monitoring, Battery State of Charge Estimation methods, Battery Cell equalization problem, thermal control, protection interface, SOC Estimation, Energy & Power estimation, Battery thermal management system, Battery Management System: Definition, Parts: Power Module, Battery, DC/DC Converter, load, communication channel, Battery Pack Safety, Battery Standards & Tests.

Pedagogy	**Chalk and talk/power point presentation**: Selection of battery for EVs & HEVs, Traction Battery Pack design, Requirement of Battery Monitoring, Battery State of Charge Estimation methods, Battery Cell equalization problem, thermal control, protection interface. **Videos/Learning material**: Battery Management System: Definition, Parts: Power Module, Battery, DC/DC Converter, load, communication channel, Battery Pack Safety, Battery Standards & Tests. **Self-study:** Battery Cell equalization problem, thermal control, protection interface

Module-5- Chemical& Structure Material for Battery Design - 08 hours

Chemical & structure material properties for cell safety and battery design, battery testing, limitations for transport and storage of cells and batteries, Recycling, disposal and second use of batteries. Battery Leakage: gas generation in batteries, leakage path, leakage rates. Ruptures: Mechanical stress and pressure tolerance of cells, safety vents, Explosions: Causes of battery explosions, explosive process, Thermal Runway: High discharge rates, Short circuits, charging and discharging. Environment and Human Health impact assessments of batteries, General recycling issues and drivers, methods of recycling of EV batteries.

Pedagogy	**Chalk and talk/power point presentation**: Chemical & structure material properties for cell safety and battery design, battery testing, limitations for transport and storage of cells and batteries, Recycling, disposal and second use of batteries. **Videos/Learning material**: Battery Leakage: gas generation in batteries, leakage path, leakage rates. Ruptures: Mechanical stress and pressure tolerance of cells, safety vents, Explosions: Causes of battery explosions, explosive process, **Self-study:** Thermal Runway: High discharge rates, Short circuits, charging and discharging.

Course outcome (Course Skill Set)

At the end of the course the student will be able to:

CO 1	Discuss about the mechanism in vehicle and about electrical vehicle.
CO 2	Analyse different types of batteries.
CO 3	Describe about the battery characteristic & parameters.
CO 4	Apply the concepts of battery management system and design the battery pack.
CO 5	Explain about the battery testing, disposal and recycling.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 100%. The minimum passing mark for the CIE is 40% of the maximum marks (400 marks out of 100). A student shall be deemed to have satisfied the academic requirements if t

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE).

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

1. First test at the end of 5th week of the semester
2. Second test at the end of the 10th week of the semester
3. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

4. First assignment at the end of 4th week of the semester
5. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

6. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module. Marks scored out of 100 shall be reduced proportionally to 50 marks

Suggested Learning Resources:

Books

1. AK Bandyopadhyay, Nanomaterials , New Age International (P) Ltd., 2nd Edition, 2010.
2. Rao. C. N, Muller. A, Cheetham . A. K, Nanomaterials chemistry, Wiley-VCH, 2007.
3. N. Kumar, Concise concepts of nanoscience and nanomaterials, Scientific publishers, 2018

Suggested Learning Resources:

Books

1. Pistoia, J.P. Wiaux, S.P. Wolsky, Used Battery Collection and Recycling, Elsevier, 2001.
2. Chris Mi, Abul Masrur& David Wenzhong Gao, Hybrid electric Vehicle- Principles & Applications with Practical Properties, Wiley, 2011.
3. Arno Kwade, Jan Diekmann, Recycling of Lithium-Ion Batteries: The LithoRec Way, Springer, 2018.
4. Ibrahim Dinçer, Halil S. Hamut and Nader Javani, Thermal Management of Electric Vehicle Battery Systems, JohnWiley& Sons Ltd., 2016.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=UgtjRob5qMg&list=PLyqSpQzTE6M9spod-UH7Q69wQ3uRm5thr
2. https://www.youtube.com/watch?v=wypbLRe9xUg

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- https://www.vlab.co.in/broad-area-chemical-sciences
- https://demonstrations.wolfram.com/topics.php
- https://interestingengineering.com/science