SRI VENKATESWARA COLLEGE OF ENGINEERING

COURSE DELIVERY PLAN - THEORY 

| Department of Automobile Engineering | LP: AE18502 |
|---|---|
| B.E/~~B.Tech/M.E/M.Tech~~ : **Automobile Engineering** Regulation: **2018** | Rev. No: 00 |
| PG Specialisation : **NA** | Date: 19.06.2020 |
| Sub. Code / Sub. Name : **AE18502 - Battery and Fuel Cell Technology for Electric Vehicles** | |
| Unit : I | |

**Unit Syllabus: INTRODUCTION TO BATTERIES**

Classification of batteries, Automotive Batteries - Principle, construction and working of lead acid battery, Advanced lead-acid batteries Horizontal plate Pb-Acid batteries for transportation, Cylindrical Pb-Acid battery vs. flat plate system, Maintenance free batteries, Battery – characteristics, rating, efficiency, testing and charging, Maintenance of batteries.

**Objective**: To understand the working principle of different types of automotive batteries.

| Session No * | Topics to be covered | Ref | Teaching Aids |
|---|---|---|---|
| 1 | Classification of batteries, Automotive Batteries | T1, R2 | PPT |
| 2 | Principle, construction and working of lead acid battery | T1, R2 | PPT |
| 3 | Advanced lead-acid batteries, Horizontal plate Pb-Acid batteries for transportation, | T1, R2 | PPT |
| 4 | Cylindrical Pb-Acid battery vs. flat plate system | T1, R2 | PPT |
| 5 | Maintenance free batteries | T1, R2 | PPT |
| 6 | Battery – characteristics | T1, R2 | PPT |
| 7 | Battery rating, efficiency | T1, R2 | PPT |
| 8 | Battery testing and charging | T1, R2 | PPT |
| 9 | Maintenance of batteries. | T1, R2 | PPT |
| **Content beyond syllabus covered (if any):** | | | |

* Session duration: 50 minutes

Sub. Code / Sub. Name: **AE18502 - Battery and Fuel Cell Technology for Electric Vehicles**

Unit : **II**

**Unit Syllabus: ENERGY STORAGE SYSTEMS**

Advanced Li-ion batteries - principle of operation, Battery components and design, Electrode, cell and battery fabrications, Lithium-Polymer batteries and applications, Lithium-Sulfur battery, Lithium-Air battery, Sodium battery, Magnesium battery, Aluminum battery, Advance Nickel-Metal Hydride batteries for transportation. Future prospects of Nickel-Metal Hydride batteries, Lithium-ion batteries - Battery Management System, Super capacitors.

**Objective:** To gain knowledge in energy storage systems available for electric vehicles.

| Session No * | Topics to be covered | Ref | Teaching Aids |
|---|---|---|---|
| 10 | Advanced Li-ion batteries - principle of operation | T1, R2 | PPT |
| 11 | Battery components and design, Electrode, cell and battery fabrications | T1, R2 | PPT |
| 12 | Lithium-Polymer batteries and applications, Lithium-Sulfur battery | T1, R2 | PPT |
| 13 | Lithium-Air battery, Sodium battery | T1, R2 | PPT |
| 14 | Magnesium battery, Aluminum battery | T1, R2 | PPT |
| 15 | Advance Nickel-Metal Hydride batteries for transportation, Future prospects of Nickel-Metal Hydride batteries | T1, R2 | PPT |
| 16 | Lithium-ion batteries - Battery Management System | T1, R2 | PPT |
| 17 | Lithium-ion batteries - Battery Management System | T1, R2 | PPT |
| 18 | Super capacitors. | T1, R2 | PPT |
| **Content beyond syllabus covered (if any):** Govt. Transport Corporation | | | |

* Session duration: 50 mins

Sub. Code / Sub. Name: **AE18502 - Battery and Fuel Cell Technology for Electric Vehicles**

Unit : **III**

**Unit Syllabus: INTRODUCTION TO FUEL CELLS**

Fuel cells: History, working principle of fuel cell, components of fuel cell – compare battery and fuel cell, Types of fuel cells – Alkaline Fuel Cell (AFC), Phosphoric Acid Fuel Cell (PAFC), Solid Oxide Fuel Cell (SOFC), Molten Carbonate Fuel Cell (MCFC), Direct Methanol Fuel Cell (DMFC), Proton Exchange Membrane Fuel Cell (PEMFC), relative merits and demerits.

**Objective:** To know the history and basic types of fuel cells.

| Session No * | Topics to be covered | Ref | Teaching Aids |
|---|---|---|---|
| 19 | Fuel cells: History, working principle of fuel cell | R3, R4 | PPT |
| 20 | Components of fuel cell | R3, R4 | PPT |
| 21 | Compare battery and fuel cell, Types of fuel cells | R3, R4 | PPT |
| 22 | Alkaline Fuel Cell (AFC) | R3, R4 | PPT |
| 23 | Phosphoric Acid Fuel Cell (PAFC), Solid Oxide Fuel Cell (SOFC) | R3, R4 | PPT |
| 24 | Molten Carbonate Fuel Cell (MCFC) | R3, R4 | PPT |
| 25 | Direct Methanol Fuel Cell (DMFC) | R3, R4 | PPT |
| 26 | Proton Exchange Membrane Fuel Cell (PEMFC) | R3, R4 | PPT |
| 27 | Relative merits and demerits. | R3, R4 | PPT |
| **Content beyond syllabus covered (if any):** | | | |

* Session duration: 50 mins

Sub. Code / Sub. Name: **AE18502 - Battery and Fuel Cell Technology for Electric Vehicles**

Unit : **IV**

**Unit Syllabus: FUEL CELL COMPONENTS AND THEIR IMPACT ON PERFORMANCE**

Fuel cell performance characteristics – current/voltage, voltage efficiency and power density, ohmic resistance, kinetic. Sizing of a Fuel Cell Stack, Stack Configuration, Stack Clamping, bi-polar plate, humidifiers and cooling plates.

**Objective:** To acquire knowledge in fuel cell components.

| Session No * | Topics to be covered | Ref | Teaching Aids |
|---|---|---|---|
| 28 | Fuel cell performance characteristics – current/voltage, voltage efficiency | R3, R4 | PPT |
| 29 | Fuel cell performance characteristics – power density, ohmic resistance, kinetic | R3, R4 | PPT |
| 30 | Sizing of a Fuel Cell Stack | R3, R4 | PPT |
| 31 | Sizing of a Fuel Cell Stack | R3, R4 | PPT |
| 32 | Stack Configuration | R3, R4 | PPT |
| 33 | Stack Clamping | R3, R4 | PPT |
| 34 | Bi-polar plate | R3, R4 | PPT |
| 35 | Humidifiers | R3, R4 | PPT |
| 36 | Cooling plates | R3, R4 | PPT |
| **Content beyond syllabus covered (if any):** | | | |

* Session duration: 50 mins

Sub. Code / Sub. Name: **AE18502 - Battery and Fuel Cell Technology for Electric Vehicles**

Unit : **V**

**Unit Syllabus: FUEL CELLS FOR AUTOMOTIVE APPLICATIONS**

Fuel cells for automotive applications – technology advances in fuel cell vehicle systems – onboard hydrogen storage – liquid hydrogen and compressed hydrogen – metal hydrides, fuel cell control system – alkaline fuel cell – road map to market.

**Objective:** To know the applications of fuel cell in automobiles.

| Session No * | Topics to be covered | Ref | Teaching Aids |
|---|---|---|---|
| 37 | Fuel cells for automotive applications | R3, R4 | PPT |
| 38 | Technology advances in fuel cell vehicle systems | R3, R4 | PPT |
| 39 | Onboard hydrogen storage - liquid hydrogen | R3, R4 | PPT |
| 40 | Onboard hydrogen storage - compressed hydrogen | R3, R4 | PPT |
| 41 | Metal hydrides | R3, R4 | PPT |
| 42 | Fuel cell control system | R3, R4 | PPT |
| 43 | Fuel cell control system | R3, R4 | PPT |
| 44 | Alkaline fuel cell | R3, R4 | PPT |
| 45 | Road map to market | R3, R4 | PPT |
| **Content beyond syllabus covered (if any):** | | | |

* Session duration: 50 mins

Sub Code / Sub Name: **AE18502 - Battery and Fuel Cell Technology for Electric Vehicles**

**TEXTBOOKS:**

1. David Linden, Thomas Reddy, "Handbook of Batteries", McGraw Hill Professional, Third Edition, 2002.
2. Gregor Hoogers, "Fuel Cell Technology Handbook", Society of Automotive Engineers, 2002.

**REFERENCES:**

1. Albert N. Link, Alan C. O'Connor and Troy J. Scot, "Battery Technology For Electric Vehicles", Routledge, 2015.
2. James Larminie, John Lowry, "Electric Vehicle Technology", Second Edition, WileyBlackwell, 2012.
3. Mehrad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles", CRC Press, 2004.
4. Ryan O'Hayre, Suk-Won Cha, Whitney G. Colella, Fritz B. Prinz, "Fuel Cell Fundamentals", Third Edition, Wiley, 2016.
5. Shripad T. Revankar and Pradip Majumdar, "Fuel Cells - Principles, Design and Analysis", CRC Press, 2014.

| | Prepared by | Approved by |
|---|---|---|
| Signature | | |
| Name | **Mr. K. PAUL DURAI** | **Dr. J. VENKATESAN** |
| Designation | Assistant Professor | HoD/AUT |
| Date | 19.06.2020 | 19.06.2020 |
| Remarks *: | Same lesson plan is followed for the academic year 2021-22 23/07/21 | 23/07/2021 |
| Remarks *: | Same lesson plan is followed for the academic year 2022-23. 25/07/22 | 25/07/2022 |

* If the same lesson plan is followed in the subsequent semester/year it should be mentioned and signed by the Faculty and the HOD

Same lesson plan is followed for the academic year 2023-24
12/07/23 12/07/2023