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**FIRST SEMESTER 2022-2023**

# Course Handout Part II

Date: 29-08-2022

In addition to part-I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

*Course No.* : ME F414

## Course Title : Fuel Cell Science & Technology

## Instructor-in-Charge : Dr. Prabakaran Saravanan (PS)

*Instructor*  : Prof. Paramesw Chidamparam (PC)

**Scope and Objective of the Course:** Fuel cell is the latest energy conversion technology with attractive advantages and is seen as potential replacement for the conventional energy devices. This course is designed to provide the in-depth understanding about the theoretical and practical aspects of the fuel cell technology. Different aspects of the fuel cell viz. fuel cell thermodynamics, electrochemistry, charge transport, mass transport and heat transfer will be covered in this course. The understanding would be useful for developing theoretical models of fuel cells. The course also discusses about experimental characterization techniques of the fuel cell viz. polarization curve, Electrochemical Impedance Spectroscopy (EIS), Current Density Mapping etc. Further, most popular fuel cell type; polymer electrolyte membrane fuel cell including direct liquid fuel cell will be discussed in detail. Other types of fuel cell which are in the development stage will also be covered in brief.

**Learning outcome:** On successful completion of this course, students will be able to:

(i) Explain about the fuel cell, types and its applications.

(ii) Demonstrate how to develop theoretical model and predict the fuel cell performance.

(iii) Demonstrate the experimental testing techniques on the fuel cell and explain the cell performance.

(iv) Understand why fuel cell designs are good or bad.

(v) Explain key issues and recent developments in the fuel cell.

**Textbooks:**

TB. 1 R. O'Hayre, S. Cha, W. Colella, F. Prinz. Fuel Cell Fundamentals. John Wiley &

Sons, New Jersey, 3rd ed., (2016).

**Reference books**

RB1. J. Larminie, A. Dicks. Fuel Cell Systems Explained. John Wiley & Son, England, 2nd ed., 2003.

RB2. M. M. Mench. Fuel Cell Engines. John Wiley & Sons, New Jersey, 2008.

RB3. C. Spiegel. Designing and Building Fuel Cells. McGraw-Hill, New York, 1st ed., 2007.

RB4. S. Srinivasan, Fuel Cells: From Fundamentals to Applications, Springer Science, New York, 2006.

**Course Plan:**

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| --- | --- | --- | --- | --- |
| **Lecture No.** | **Learning objectives** | **Topics to be covered** | **Chapter in the Text Book** | **Instructor** |
| 1-5 | Fuel cell principles | What is a fuel cell?; Advantages & Disadvantages; Fuel cell types; Basic fuel cell operation; Fuel cell operation; Fuel cell technology; Fuel cells & environment | TB1: Ch. 1 | PS |
| 6-10 | Fuel cell thermodynamics | Review of thermodynamics; Heat potential & work potential; Predicting reversible voltage of a fuel cell under non-standard conditions; Fuel cell efficiency; Thermal and Mass balance in fuel cells; Thermodynamics of reversible fuel cell | TB1: Ch. 2 | PS |
| 11-15 | Fuel cell reaction kinetics | Electrochemical reaction basics, Faraday’s law , Tafel equation, Butler – Volmer equation, exchange current | TB1: Ch. 3 | PS |
| 16-19 | Fuel cell charge transport | Voltage loss due to charge transport, ion transport in different electrolytes, electron transport | TB1: Ch. 4 | PS |
| 20-22 | Fuel cell mass transport | Mass transport in electrodes (diffusive), mass transport in flow channels (convective), fuel crossover, heatgeneration and transport | TB1: Ch. 5 | PS |
| 23-27 | Fuel cell characterization | In-situ versus ex-situ characterization, fuel cell testing setup, polarization curve, fuel cell resistance, current density mapping, characterization of fuel cell layers | TB1: Ch. 7 | PC |
| 28-32 | Overview of fuel cell types | Phosphoric acid fuel cell; Polymer electrolyte membrane fuel cell; Alkaline fuel cell; Molten carbonate fuel cell; Solid oxide fuel cells; Other fuel cells. | TB:1 Ch. 8 | PC |
| 33- 39 | Overview of fuel subsystems | Fuel cell subsystem; Thermal management subsystem; Fuel delivery subsystem; Power electronics subsystems; Case studies. | TB:1 Ch. 10 | PC |
| 40-42 | Environmental impact of fuel cells | Life cycle assessment (LCA); Important emissions for LCA; Emissions related to global warming & air pollution; Analysing various scenarios | TB:1 Ch. 14 | PC |

**Evaluation Scheme:**

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| **Evaluation component** | **Duration** | **Weightage (%)** | **Date/Time/Venue** | **Evaluation type** |
| Quiz 1 | 30 min | 10 | September | Closed book |
| Mid-Semester Test | 90 min | 30 | 31/10 11.00 - 12.30PM | Closed book |
| Quiz 2 | 30 min | 10 | November | Open book |
| Comprehensive Examination | 180 min | 35 | 17/12 AN | Closed book |
| Project (Term paper and Report) |  | 15 |  | Open book |

\* Best 3 out of 4 class tests.

# Term paper report (10%) and presentation (10%).

**Chamber Consultation Hour:** Thursday afternoons 4 to 5 pm.

**Notices:** All notices concerning this course will be displayed on CMS.

**Make-up Policy:** Make-up will be granted only to genuine cases. For cases related to illness, proper documentary evidence is essential. Prior permission is necessary if the student is out of station on the test date.

**Academic Honesty and Integrity Policy:** Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

**INSTRUCTOR-IN-CHARGE**