



**Birla Institute of Technology & Science, Pilani**  
Hyderabad Campus

**FIRST SEMESTER 2020-2021**

**Course Handout Part II**

Date: 17-08-2020

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* : Sujith R  
*Instructor* : Prabakaran Saravanan

**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:

Lecture No.	Learning objectives	Topics to be covered	Chapter in the Text Book
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
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
11-15	Fuel cell reaction kinetics	Electrochemical reaction basics, Faraday's law, Tafel equation, Butler – Volmer equation, exchange current	TB1: Ch. 3
16-19	Fuel cell charge transport	Voltage loss due to charge transport, ion transport in different electrolytes, electron transport	TB1: Ch. 4
20-22	Fuel cell mass transport	Mass transport in electrodes (diffusive), mass transport in flow channels (convective), fuel crossover, heat generation and transport	TB1: Ch. 5
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
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
33- 39	Overview of fuel subsystems	Fuel cell subsystem; Thermal management subsystem; Fuel delivery subsystem; Power electronics subsystems; Case studies.	TB:1 Ch. 10
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

## Evaluation Scheme:

Component	Duration	Weightage (%)	Date & Time	Nature of Component
Test 1	30 minutes	10	September 10 – September 20 (during scheduled class Hour)	Open book
Test 2	30 minutes	15	October 9-October 20(during scheduled class hour)	Open book
Test 3	30 minutes	15	November 10-November 20 during scheduled class hour)	Open book
Project <sup>#</sup>		20		Open book
Class quizzes*		10		Open book
Comprehensive Examination		30	TBA	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**

