| Course Code ESE-814 | Credit Hours (Th-Pr) 3.0-0 | **Fuel Cell (Elective)** | Contact Hrs/Week (Th-Pr) 3.0-0 | Total Contact Hrs (Th-Pr) 45-0 |
|---|---|---|---|---|

**Course Outline:**

This course will cover from fundamentals to system applications of current fuel cell technologies. Following major types of fuel cells will be discussed: polymer electrolyte membrane fuel cell (PEMFC), direct methanol Fuel Cells (DMFC), Alkaline Fuel Cells (AFC), phosphoric acid fuel cell (PAFC), molten carbonate fuel cell (MCFC) and solid oxide fuel cell (SOFC). The emphasis will be the performance behavior, analysis, and modeling. Subsequently, the balance of the fuel cell power plant, thermal system design and analysis will be discussed that affect the power generation. Finally, the components needed, issues related, and pertinent analysis will be covered to delivering electric power generated from the fuel cell.

**Eligibility Criteria:**

B.E in Mech., Elect (Power), Chemical, Industrial, Process

B.S (4-years) Or M.Sc. degrees in Physics

**Recommended Books**:

| S. No. | Title | Author(s) | Assigned Code | Remarks |
|---|---|---|---|---|
| 1. | Fuel Cell Fundamentals | Ryan O'Hayre, Suk-Won Cha, Whitney Colella | RH | Text |
| 2. | Fuel Cells: Principles, Design, and Analysis | Shripad T. Revankar, Pradip Majumdar | ST | Reference |
| 3. | Hydrogen and Fuel Cells | Bent Sorensen | BS | Reference |
| 4. | Fuel Cell Technology | Sammes, Nigel | SN | Reference |

**Course Objectives:**

Main goal of the current course is to prepare the students who are interested in fuel cell research with fundamentals of fuel cell operating principles, what are the critical issues to be solved for their applications, and current technology development worldwide. The course will provide a thorough understanding of performance characteristics of fuel cell power plant and its components. Also it will outline the performance and design characteristics and operating issues for various fuel cells. Thus at the successful end of the course, the students will have sufficient knowledge for working in a fuel cell industry or R&D organization

**Learning outcome:**

At the end of the course student will be able to

- Apply know-how of thermodynamics, electrochemistry, heat transfer, and fluid mechanics principles to design and analysis of this emerging technology.
- Have thorough understanding of performance behavior, operational issues and challenges for all major types of fuel cells.
- Identify, formulate, and solve problems related to fuel cell technology keeping in mind economic viability.
- Use the techniques, skills, and modern engineering tools necessary for design and analysis of innovative fuel cell systems.
- Understand the impact of this technology in a global and societal context.
- Develop enough skills to design systems or components of fuel cells.
- Be ready to begin a career as an engineer in companies developing fuel cell components and systems.

**Topics Covered:**

| No. | Topics | Text Books | Allocated Periods |
|---|---|---|---|
| 1. | Hydrogen as Fuel: Hydrogen as a Fuel, Different Hydrogen Production Methods, Hydrogen Storage | | 8 |
| 2. | Fuel Cells: Fuel Cell Working Principle, Thermodynamics and Electrochemical principles, V-I Diagram, Components of Fuel Cells. | | 8 |

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| 3. | Types to Fuel Cells: Basis of Classification, Polymer Electrolyte Membrane (PEM), Direct Methanol Fuel Cells (DMFC), Alkaline Fuel Cells, Phosphoric Acid Fuel Cells, Molten Carbonate Fuel Cells, Solid Oxide Fuel Cells (SOFC) | | 8 |
| 4. | Materials in Fuel Cells and there advancements: Fuel Cell Materials, Electrolytes, Fuel Cell Electrodes, Substrates, Fuel Cell Stacks | | 6 |
| 5. | Fuel Cells Applications: Fuel Cell Applications for Power, Fuel Cell Applications for Transportation. Fuel Cells for Stationary Devices, Fuel Cells for Portable devices | | 8 |
| 6. | Fuel Cell Process Design<br>Operating and design variables<br>Examination of process flow diagrams<br>Theoretical and practical efficiencies: trade-off of heat and work<br>Rankine and Brayton cycles<br>SOFC - gas turbine combined cycle system<br>PEM system: material recycle and heat integration | | 5 |
| 7. | Fuel Cell Advancements: Micro Fuel Cells, Fuel cells usage in Submarine and Satellites. Special Applications | | 4 |
| 8 | Design modelling and simulation of fuel cells | | |