

### HYDROGEN AND FUEL CELL TECHNOLOGY

|                                        |                         |                                 |            |                       |          |
|----------------------------------------|-------------------------|---------------------------------|------------|-----------------------|----------|
| <b>Course Code</b>                     | <b>23ME4702A</b>        | <b>Year</b>                     | <b>IV</b>  | <b>Semester</b>       | <b>I</b> |
| <b>Course Category</b>                 | Professional Elective-V | <b>Branch</b>                   | Mechanical | <b>Course Type</b>    | Theory   |
| <b>Credits</b>                         | 3                       | <b>L-T-P</b>                    | 3-0-0      | <b>Pre-requisites</b> | NIL      |
| <b>Continuous Internal Evaluation:</b> | 30                      | <b>Semester End Evaluation:</b> | 70         | <b>Total Marks:</b>   | 100      |

| Course Outcomes                                                       |                                                                                                                                                      |                     |
|-----------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| Upon successful completion of the course, the student will be able to |                                                                                                                                                      | <b>Blooms Level</b> |
| <b>CO1</b>                                                            | Understand the properties of hydrogen as a fuel and describe the infrastructure requirements for its production, storage, and utilization.           | <b>L2</b>           |
| <b>CO2</b>                                                            | Analyze various hydrogen production methods including thermal, electrochemical, and biological processes.                                            | <b>L3</b>           |
| <b>CO3</b>                                                            | Evaluate different hydrogen storage technologies such as compressed, cryogenic, and solid-state systems with their respective merits and challenges. | <b>L3</b>           |
| <b>CO4</b>                                                            | Examine the applications of hydrogen in IC engines, power generation, domestic usage, and hybrid fuel systems.                                       | <b>L3</b>           |
| <b>CO5</b>                                                            | Understand the working principles, types, performance, and applications of various fuel cells and distinguish them from conventional batteries.      | <b>L3</b>           |

| <b><u>Strength of Correlation between CO – PO , CO- PSO in scale of 1-3- Course Articulation Matrix</u></b> |            |            |            |            |            |            |            |            |            |             |             |             |             |
|-------------------------------------------------------------------------------------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
| <b>CO-PO Mapping</b>                                                                                        | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> | <b>PSO1</b> | <b>PSO2</b> |
| <b>CO1</b>                                                                                                  | 3          | 3          | 2          | 2          | -          | 2          | 2          | -          | -          | -           | -           | 3           | 2           |
| <b>CO2</b>                                                                                                  | 3          | 3          | 2          | 3          | -          | 2          | 2          | -          | -          | -           | -           | 3           | 2           |
| <b>CO3</b>                                                                                                  | 3          | 3          | 2          | 3          | -          | 2          | 2          | -          | -          | -           | -           | 3           | 2           |
| <b>CO4</b>                                                                                                  | 3          | 3          | 2          | 3          | -          | 2          | 2          | -          | -          | -           | -           | 3           | 2           |
| <b>CO5</b>                                                                                                  | 3          | 3          | 2          | 3          | -          | 2          | 2          | -          | -          | -           | -           | 3           | 2           |

| <b>SYLLABUS</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                              |                  |
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| <b>Unit No.</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Contents</b>                                                                                                                                                                                                                                                                                                              | <b>Mapped CO</b> |
| <b>I</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>INTRODUCTION OF HYDROGEN ENERGY SYSTEMS:</b> Properties of hydrogen as fuel, Hydrogen pathways introduction-current uses, general introduction to infrastructure requirement for hydrogen production, storage, dispensing, utilization, safety and hydrogen production plants.                                            | <b>CO1</b>       |
| <b>II</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>HYDROGEN PRODUCTION PROCESSES:</b> Thermal-Steam reformation, thermo chemical water splitting, gasification-pyrolysis, nuclear thermal catalytic and partial oxidation methods, Electrochemical-Electrolysis, photo electro chemical, Biological-Anaerobic digestion, fermentation micro organism, PM based electrolyser. | <b>CO1, CO2</b>  |
| <b>III</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>HYDROGEN STORAGE:</b> Physical and chemical properties, general storage methods, compressed storage-composite cylinders, glass micro sphere storage, zeolites, metal hydride storage, chemical hydride storage and cryogenic storage, carbon based materials for hydrogen storage.                                        | <b>CO1, CO3</b>  |
| <b>IV</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>HYDROGEN UTILIZATION:</b> Overview of hydrogen utilization, IC Engines, gas turbines, hydrogen burners, power plant, domestic cooking gas, marine applications, hydrogen dual fuel engines.                                                                                                                               | <b>CO1, CO4</b>  |
| <b>V</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>FUEL CELLS:</b> History – principle - working - thermodynamics and kinetics of fuel cell process –performance evaluation of fuel cell – comparison on battery Vs fuel cell, Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC, microbial fuel cells, relative merits and demerits and application of fuel cells.   | <b>CO1, CO5</b>  |
| <b>Learning Recourses</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                              |                  |
| <b>Text Books:</b> <ol style="list-style-type: none"> <li>1. Sorenson B, Hydrogen and Fuel Cells: Emerging Technologies and Applications, Bent Sorenson, Academic Press (2005).</li> <li>2. Hordeski MF, Hydrogen and Fuel Cells: Advances in Transportation and Power, The Fairmont Press, Inc. (2009)</li> <li>3. Busby RL, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Books (2005).</li> </ol> <b>References:</b> <ol style="list-style-type: none"> <li>1. Viswanathan B. and Aulice Scibioh.M, Fuel Cells – Principles and Applications, Universities Press, 2006.</li> <li>2. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation,</li> <li>3. Hart A.B. and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, New York Ltd., London 1989.</li> <li>4. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA 2002.</li> <li>5. Barclay F.J., Fuel Cells, Engines and Hydrogen, Wiley, 2009.</li> </ol> |                                                                                                                                                                                                                                                                                                                              |                  |

