NATIONAL INSTITUTE OF TECHNOLOGY, TIRUCHIRAPPALLI

DEPARTMENT OF Chemical Engineering

COURSE PLAN – PART I			
Name of the programme and specialization	**M.Tech Chemical**		
Course Title	**Fuel Cell Technology**		
Course Code	**CI 619**	**No. of Credits**	**3**
Course Code of Pre-requisite subject(s)	**None**		
Session	**January 2019**	**Section (if, applicable)**	**Not applicable**
Name of Faculty	**G.Arthanareeswaran**	**Department**	**Chemical Engineering**
Official Email	**arthanareeg@nitt.edu**	**Telephone No.**	**3118**
Name of Course Coordinator(s) (if, applicable)	**Not applicable**		
Official E-mail		**Telephone No.**	
Course Type (please tick appropriately)	☐ **Core course**	■ **Elective course**	

Syllabus (approved in BoS)

Basic principles, classifications, heat of reactions, enthalpy of formation of substances, Gibbs free energy of substances, Efficiency, power, heat due to entropy change and internal ohmic heating.

Nernst equation and open circuit potential, pressure and temperature effect -Stoichiometric coefficients and reactants utilization - Mass flow rate calculation - voltage and current in parallel and serial connection–Over potentials andpolarizations - Activation polarization - Tafel equation and exchange current density –Ionic conductivity, catalysts, Temperature and humidification effect, electro-osmotic Drag effect.

PEM Fuel Cell components: Anode and Cathode materials, catalysts, membrane, Fuels for fuel cells- PEM Fuel cell stacks - Rate of mass transfer of reactants and products - water management – current collections and gas removal- Bipolar plates- flow distribution – Heat and water removal from the stack.

Fuel cell systems analyze: Energy systems, power- Train or Drive-Train Analysis – PEMFC powered Bus- Flow Sheet and conceptual Design-Detailed Engineering Designs

COURSE OBJECTIVES

To understand about fuel cells, their working principle, Types, Design and performance analysis

MAPPING OF COs with POs

Course Outcomes	**Programme Outcomes (PO)** (Enter Numbers only)
1. Know the basics and working principles of the Fuel cell technology.	**PO1**

2. Select the suitable materials for electrode, catalyst, membrane for the fuel cells.	**PO1 PO2 PO3 PO4 PO5 PO7 PO8 PO11**
3. Understand the pressure drop and velocity distribution in single cell as well as stack.	**PO1 PO2 PO4 PO5 PO6 PO7 PO8 PO11**
4. Design and stack making process for real field applications.	**PO1 PO2 PO3 PO4 PO5 PO6 PO7 PO8 PO10 PO11**

COURSE PLAN – PART II

COURSE OVERVIEW

Fuel cell technology course gives an insight into concepts of electrochemical reaction, Stoichiometric reaction in fuel cells. The Types and working principle of all fell cells and design and performance analysis also taught

COURSE TEACHING AND LEARNING ACTIVITIES (Add more rows)

S.No.	Week/Contact Hours	Topic	Mode of Delivery
1.	Week 1	Introduction to Fuel Cell technology – Overview	Chalk and talk
2.	Week 1	Basic electrochemistry for all the fuel Basic principles, classifications of Electocemical reactions	PPT
3.	Week 1	Heat of reactions, enthalpy of formation of substances	PPT
4.	Week 2	Efficiency, power generation	PPT
5.	Week 2	Heat due to entropy change and internal ohmic heating.	PPT
6.	Week 2	Fuel Cells Thermodynamics	PPT
7.	Week 3	Electrode potential and Electrochemical Potential	Chalk and Board
8.	Week 3	Nernst equation and open circuit potential, pressure and temperature effect	PPT

9.	Week 3	Stoichiometric coefficients and reactants utilization	PPT
10.	Week 4	Activation over-potential	PPT
11.	Week 4	Mass flow rate calculation -	PPT
12.	Week 4	Voltage and current in parallel and serial connection	PPT
13.	Week 5	Over potentials andpolarizations	PPT
14.	Week 5	Concentration Polarization	PPT
15.	Week 5	Transport of Electricity: Ohmic Polarization	PPT
		Assessment I	--
16.	Week 6	Graphical representation of the factors that contributes to fuel cell performance	Chalk and Board
17.	Week 6	Activation polarization	PPT
18.	Week 6	Tafel equation and exchange current density	PPT
19.	Week 7	Ionic conductivity, catalysts	PPT
20.	Week 7	Temperature and humidification effect	Chalk and talk

21.	Week 7	electro-osmotic Drag effect.	PPT
22.	Week 8	Fuel Cell Components	PPT
23.	Week 8	Basics of Ionic Transport in PEM	Chalk and Board
24.	Week 8	Anode and Cathode materials, catalysts,	Chalk and Board
25.	Week 9	membrane, Fuels for fuel cells	Chalk and Board
26.	Week 9	Fluorinated polymer based PEM	Chalk and Board
27.	Week 9	Acid-base blends type PEM, Hydrocarbon polymer based PEM	Chalk and Board
28.	Week 10	Electrolyte : Proton conductivity; cross-over. Bipolar plate : Mechanical and chemical strength; flow field design;	PPT
29.	Week 10	Catalyst : Surface area; selectivity Gas diffusion layer : Porosity; hydropholicity; hydrophilicity; strength	Chalk and Board
30.	Week 10	Rate of mass transfer of reactants and products - water management, electrical conductivity	PPT
		Assessment II	
31.	Week 11	Heat and water removal from the stack.	Chalk and Board
32.	Week 11	Fuel cell systems analyze: Energy systems,	Chalk and Board

33.	Week 11	power- Train or Drive-Train Analysis	PPT
34.	Week 12	Application of Fuel cell powered Bus	Chalk and Board
35.	Week 12	Flow Sheet and conceptual Design Detailed Engineering Designs	PPT
36.	Week 12	Hydrogen Generation, Hydrogen Storage	PPT

COURSE ASSESSMENT METHODS (shall range from 4 to 6**)**

S.No.	Mode of Assessment	Week/Date	Duration	% Weightage
1	Assesssment I	End of 5th week since commencement	1 hour	20%
2	Assessment II	End of 10h week since commencement	1 hour	20%
3	Assessment III – (Seminar)	In between the course as mentioned in the course plan	30 minutes in the class	20 % (Average)
CPA	Compensation Assessment*	After 12th week	1 hour	20%
5	Final Assessment*	At the end of Course	3 hours	40%

***mandatory; refer to guidelines on page 4**

COURSE EXIT SURVEY (mention the ways in which the feedback about the course shall be assessed)

REFERENCE BOOKS

1. James Larminie and Andrew Dicks, Fuel Cell Systems Explained, 2nd Edition, John Wiley & Sons Inc., 2000.
2. FranoBarbir, PEM Fuel Cells Theory and Practice, Elsevier Academic Press, 2005.
3. GregorHoogers, Fuel Cell Technology, Handbook, SAE International, 2003.
   B Viswanathan and M AuliceScibioh, Fuel Cell Principles and Applications, University Press, 2006.

COURSE POLICY (including compensation assessment to be specified**)**

1) Feed back is planned to be collected thrice; At class committee meetings during the assessment period and one at the end of course as soon as classes are over.

2) The academic performance of the students will be assessed based on **Two** assessments by written test (each 20 marks), Assignment test (20 marks) during the course and **One** final assessment (50 marks) at the end of course.

Suitable mapping of COs with POs will be made and attainment will be calculated.

ATTENDANCE POLICY (A uniform attendance policy as specified below shall be followed)

- At least 75% attendance in each course is mandatory.
- A maximum of 10% shall be allowed under On Duty (OD) category.
- Students with less than 65% of attendance shall be prevented from writing the final assessment and shall be awarded 'V' grade.

ACADEMIC DISHONESTY & PLAGIARISM

- Possessing a mobile phone, carrying bits of paper, talking to other students, copying from others during an assessment will be treated as punishable dishonesty.
- Zero mark to be awarded for the offenders. For copying from another student, both students get the same penalty of zero mark.
- The departmental disciplinary committee including the course faculty member, PAC chairperson and the HoD, as members shall verify the facts of the malpractice and award the punishment if the student is found guilty. The report shall be submitted to the Academic office.
- The above policy against academic dishonesty shall be applicable for all the programmes.

ADDITIONAL INFORMATION, IF ANY

COURSE POLICY (preferred mode of correspondence with students, policy on attendance, compensation assessment, , academic honesty and plagiarism etc.)

1) It is expected that the students will not indulge in any form of malpractice in Examinations. Students must attend all the assignment tests, and the average will be taken for its weightage.
2) **One Compensation assessment** will be conducted only for absentees in either the Assessments or Assignment tests under Medical or Institute related activities.
3) Attendance of **70% is mandatory**. Students with **attendance below 50%** will be **prevented** to attend the final assessment examination.
4) Students with attendance **between 50 – 70% under genuine medical reasons** will be allowed to attend the compensation classes to meet out attendance criteria.

MODE OF CORRESPONDENCE (email/ phone etc)
arthanareeg@gmail.com, 9940361673
ADDITIONAL INFORMATION
eg.: The Course Coordinator is available for consultation and Queries may also be emailed to the Course Coordinator directly at arthanareeg@gmail.com
5) It is expected that the students will not indulge in any form of malpractice in
FOR APPROVAL
Course Faculty ______ Dr. G. Arthanareeswaran, **CC- Chairperson** ______ **HOD** ______

Guidelines

a) The number of assessments for any theory course shall range from 4 to 6.

b) Every theory course shall have a final assessment on the entire syllabus with at least 30% weightage.

c) One compensation assessment for absentees in assessments (other than final assessment) is mandatory. Only genuine cases of absence shall be considered.

d) The passing minimum shall be as per the regulations.

B.Tech. Admitted in				**P.G.**
2018	**2017**	**2016**	**2015**	
35% or (Class average/2) whichever is greater.		(Peak/3) or (Class Average/2) whichever is lower		40%

e) Attendance policy and the policy on academic dishonesty & plagiarism by students are uniform for all the courses.

f) Absolute grading policy shall be incorporated if the number of students per course is less than 10.

g) Necessary care shall be taken to ensure that the course plan is reasonable and is objective.