M.Tech (Chemical and Electrochemical Engineering)

CURRICULUM

SEMESTER I						SEMESTER II					
Course Code	**Course Title**	**L**	**T**	**P**	**C**	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
ENG(CECRI) 1-111	Advanced Mathematical Techniques in Chemical Engineering	3	0	0	3	ENG(CECRI) 2-211	Electrochemical Engineering	3	0	0	3
ENG(CECRI) 1-112	Computational Fluid Dynamics	3	0	0	3		Elective I	3	0	0	3
ENG(CECRI) 1-113	Electrodics and Electrocatalysis	3	0	0	3		Elective II	3	0	0	3
ENG(CECRI) 1-114	Industrial Electrochemistry	3	0	0	3		Elective III	3	0	0	3
ENG(CECRI) 1-115	Advanced Materials Characterization Techniques	3	0	0	3	ENG(CECRI) 2-212	Research Methodology	2	0	0	2
ENG(CECRI) 1-116	Advanced Materials Characterization Lab	0	0	6	3	ENG(CECRI) 2-213	Seminar I	0	0	4	2
						ENG(CECRI) 2-214	Electrochemical Engineering Lab	0	0	6	3
	Total Credits	**18**				**Total Credits**		**19**			

SEMESTER III						SEMESTER IV					
Course Code	**Course Title**	**L**	**T**	**P**	**C**	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
ENG(CECRI) 3-311	Electrochemical Reaction Engineering	3	0	0	3	ENG(CECRI) 4-411	Dissertation-II and Viva-Voce	0	8	24	20
ENG(CECRI) 3-312	Design and Analysis of Experiments	2	0	0	2						
ENG(CECRI) 3-313	Seminar II	0	0	4	2						
ENG(CECRI) 3-314	Dissertation I	0	4	16	12						
	Total Credits	**19**					**Total Credits**	**20**			

Total Credits : 76

ELECTIVES

Course Code	Course Title	L	T	P	C
ENG(CECRI) 2-221	Multiphase Flow	3	0	0	3
ENG(CECRI) 2-222	Process Modelling and Simulation	3	0	0	3
ENG(CECRI) 2-223	Advanced Process Dynamics & Control	3	0	0	3
ENG(CECRI) 2-224	Process Synthesis and Design	3	0	0	3
ENG(CECRI) 2-231	Corrosion Engineering	3	0	0	3
ENG(CECRI) 2-232	Bio Electrochemistry	3	0	0	3
ENG(CECRI) 2-233	Photoelectrochemical Solar cells, Thin Film Devices & their Application	3	0	0	3
ENG(CECRI) 2-234	Organic Electrochemistry	3	0	0	3
ENG(CECRI) 2-241	Electrochemical Power Systems for Electric Vehicles	3	0	0	3
ENG(CECRI) 2-242	Maintenance Free Electrochemical Energy Conversion & Storage	3	0	0	3
ENG(CECRI) 2-243	Fuel Cells : Science & Engineering	3	0	0	3
ENG(CECRI) 2-244	Electrochemical Supercapacitors	3	0	0	3

SYLLABUS

SEMESTER I

ENG(CECRI)1-111 ADVANCED MATHEMATICAL TECHNIQUES IN CHEMICAL ENGINEERING	L-T-P-C 3-0-0-3

Introduction of vector space;Metric, Norm, Inner Product space;Examples
Onto, into, one to one function, completeness of space

Vectors: Linear combination of vectors, dependent/independent vectors; Orthogonal and orthonormal vectors; Gram-Schmidt orthogonalization; Examples

Contraction Mapping: Definition; Applications in Chemical Engineering; Examples

Matrix, determinants and properties

Eigenvalue Problem:Various theorems; Solution of a set of algebraic equations; Solution of a set of ordinary differential equations; Solution of a set of non homogeneous first order ordinary differential equations (IVPs)

Applications of eigenvalue problems: Stability analysis; Bifurcation theory; Examples

Partial Differential equations:Classification of equations; Boundary conditions;Principle of Linear superposition

Special ODEs and Adjoint operators:Properties of adjoint operator; Theorem for eigenvalues and eigenfunctions;

Solution of linear, homogeneous PDEs by separation of variables: Cartesian coordinate system & different classes of PDEs; Cylindrical coordinate system ; Spherical Coordinate system

Solution of non-homogeneous PDEs by Green's theorem

Solution of PDEs by Similarity solution method

Solution of PDEs by Integral method

Solution of PDEs by Laplace transformation

Solution of PDEs by Fourier transformation

References:

1. S. Pushpavanam, “Mathematical Methods in Chemical Engineering” Prentice Hall of India.
2. R. G. Rice & D. D. Do, “Applied Mathematics and Modeling for Chemical Engineers” Wiley
3. A. Varma & M. Morbidelli, “Mathematical Method in Chemical Engineering” Oxford University Press.
4. N. W. Lone, “Applied Mathematical Methods for Chemical Engineers” CRC Press.

Faculty:

S. Sivakumar

ENG(CECRI)1-112	COMPUTATIONAL FLUID DYNAMICS	L-T-P-C 3-0-0-3

Illustration of the CFD approach; CFD as an engineering analysis tool.

Derivation of flow governing equations; turbulence modeling; modeling approaches for multiphase flow; initial and boundary conditions; wellposedness.

Discretization of the governing equations using finite difference/volume/element methods; concepts of consistency, stability and convergence; template for the discretization of a generic unsteady transport equation.

Solution of discretized equations; direct methods; classical iterative methods; advanced methods for structured matrices; conjugate gradient techniques; multigrid methods.

Solution of coupled equations: methods for compressible flows; evaluation of pressure in incompressible flows; pressure-velocity coupling algorithms.

Structured and unstructured grids; structured grid generation; unstructured grid generation.

Benchmarking; calibration.

References:

1. C Hirsch, “Numerical Computation of Internal and External Flows”, Vol.1 and 2, John Wiley, 1990.

2. J H Ferziger and M Peric, Computational Methods for Fluid Dynamics, Springer, 2002

Faculty

Dr. C. Naveen Kumar and Dr. Sundar Mayavan

ENG(CECRI)1-113	ELECTRODICS AND ELECTROCATALYSIS	L-T-P-C 3-0-0-3

Electrical Double Layer

Thermodynamics of ideally polarizable and non-polarizable interfaces- Lipman equation- determination of interfacial tension, charge density, surface excess and double layer capacitance by electro capillary & bridge methods- Helmholtz, Gouy-Chapman and stern models of the double layer with discussion of potential and charge distribution inside the double layer-contact adsorption and its determination.

Electrode Kinetics

Concepts of equilibrium potential, Nernst equation, overpotential and its different types, equilibrium exchange current density-derivation of Butler-Volmer equation –high field and low field approximations – charge transfer resistance and polarizability of the interface – concepts of rate determining step, Stoichiometric number, reaction order – Determination of kinetics parameters [i_o, k_s, $\beta(\alpha)$] by Tafel and linear polarization methods.

Electrocatalysis

Chemical catalysis and electro catalysis – comparison of electrocatalysts – electro catalysis in simple redox reactions involving adsorbed species – electronic and geometric factors in electrocatalysts -Discussion on the mechanisms of hydrogen evolution and oxygen reduction reactions.

Electrochemical Techniques I

Ion selective electrodes – Principles of potentiometry and amperometry- determination of dissolved oxygen. Linear sweep voltammetry and cyclic voltammetry derivation of Randles- Sevciks equation – effect of sweep rate-analysis of cyclic voltammograms.

Electrochemical Techniques II

Potential step method (chronoamperometry) under diffusion control derivation of Cottrell equation for a planar and spherical electrode- significance of spherical diffusion – derivation of Ilkovic equation.- Chronopotentiometry and analysis of chronopotentiograms-derivation of sands equation for constant current input under linear diffusion- concepts of Faradaic impedance –derivation of kinetic parameters from impedance measurements – Nyquist and bode plots for simple redox reactions-principles of scanning probe techniques-STM-AFM and SECM – working principles of electrochemistry.

Text Books

1. J.O.M Bockris & A.K.N. Reddy, “Modern Electrochemistry”, Vol.2, Plenum Press (Chapter 7 for unit I: Chapters 8 & 9 for unit II ; chapter 10 for unit III), 1996.
2. A.J.Bard & L.R. Faulkner, ”Electrochemical Methods Fundamentals and Applications”, John Wiley & Sons. 3nd Edition, 2001.

References

1. Paul Delahay, “Double Layer Structure and Electrode Kinetics”, 1965 and publication.
2. James A. Plam Beck , “Electroanalytical Chemistry – Basic Principles and Applications”, John Wiley & sons, Wiley Publication, 1982

Faculty

Dr. Vijayamohanan K.Pillai, Dr.Sheela Berchmans, Dr. V. Ganesh

ENG(CECRI)1-114	INDUSTRIAL ELECTROCHEMISTRY	L-T-P-C 3-0-0-3

Fundamental concepts, electron transfer, mass transfer, adsorption, electrocatalysis, phase formation in electrode reaction, assessment of cell voltage, costing of electrolytic process, performance and figure of merit. Typical cell designs. Laboratory data and scale-up.

Chlor-alkali industry- concept of brine electrolysis, chlorine cell technology, the production of NaOH. Water electrolysis, sodium chlorate, hydrogen peroxide, ozone, cuprous oxide, and synthesis of metal salt via anodic dissolution, Organic electro synthesis-dimerization of acrylonitrile, indirect electrosynthesis.

The extraction, refining and production of metal- electrowinning, cementation, electrorefining, electrodeposition of metal powders. Corrosion and its control- thermodynamics and kinetics of corrosion reactions, corrosion problem in practice, corrosion prevention and control, corrosion problems in electrolytic processing, corrosion measurement and monitoring.

Metal finishing- electroplating, electroless plating, conversion coatings, electroforming, electrochemical etching. Batteries and fuel cells- battery characteristics, battery specification, evaluation of battery performance, battery components. Fuel cells.

Water purification, effluent treatment and recycling of industrial process stream- metal ion removal and recovery, treatment of liquors containing dissolved chromium, electrolytic method of phase separation, flue gas desulphurization, electrodialysis. Electrochemical sensor and monitoring techniques, paleographic to anodic stripping voltammetry, ion selective electrode, electrochemical biosensors.

Text Book

1. Derek Pletcher and Frank C Walsh, “Industrial Electrochemistry”, 2nd edition, Chapman & Hall, UK, 1990
2. A.T.Kuhn, “Industrial Electrochemistry”, Elsevier Publishers, 1972.

Reference Books

1. C.L. Mantell, “Chemical Engineering Series – Industrial Electrochemistry”, Mc Graw Hill Co., Inc. London, 1958
2. Ullmann’s “Encyclopedia of Industrial Chemistry”, John Wiley & Sons, Vol.6, pp: 399- 481, 2003.
3. Krik – “Othmer Encyclopedia of Chemical Technology”, 4th edition, Vol: I., Pp 938 – 1025 (1991)
4. N.M.Prout And J.S.Moorhouse, “Modern Chlor – Alkali Technology”, Vol. IV, Elsevier Applied Science, London, 1990.

Faculty

Dr. Sheela Berchmans, Dr. K. Subramanian, Dr. D. Vasudevan, Dr. V.Nandakumar, Dr.Rakesh Barik, Dr. G.N.K. Ramesh Bapu, Shri S. Ambalavanan, Dr. B. Ramesh Babu, Dr. J. Mathiyarasu

ENG(CECRI)1-115	ADVACNED MATERIALS CHARACTERIZATION TECHNIQUES	L-T-P-C 3-0-0-3

Optical and Electron Microscopy:
Microscopic examination of materials, morphology and microstructure, Principle and application of Scanning Electron Microscope, Transmission Electron Microscope, High resolution Transmission Electron Microscope and Specimen preparation methods. Energy Dispersive X-ray analysis (EDS) and Electron Probe Microanalysis (EPMA) for chemical composition of materials

X-ray Techniques
Principles of X-ray diffraction (XRD) and electron diffraction for phase analysis of materials, Electron Spectroscopy for Chemical Analysis (ESCA), X-ray fluorescence, Auger electron spectroscopy

Spectroscopic techniques
Principle and application of UV-VIS-NIR, FTIR, RAMAN spectroscopy.

Thermal analysis techniques
Thermo Gravimetric Analysis (TGA) / Differential Thermal Analysis (DTA)

Magnetic Resonance techniques
Electron Spin Resonance and Nuclear Magnetic Resonance Spectrometer principle and applications

Scanning Probe techniques
Atomic Force Microscopy, Scanning tunneling microscope and scanning Vibrating electrode setup.

References:

1. Andrew J. Milling, Marcel Dekker, “Surface Characterization Methods, Principles, Techniques and applications”, 1999 – 192 pages

2. J.M.Walls, “Methods of Surface Analysis: Techniques and Applications”

Faculty

Dr. R.H. Suresh Bapu

ENG(CECRI)1-116	ADVANCED MATERIALS CHARACTERIZATION LAB	L-T-P-C 0-0-6-3

1. UV-VIS-NIR Spectrophotometer
2. FTIR Spectrophotometer
3. Raman Spectrometer
4. Scanning Electron Microscope
5. Field Emission Scanning Electron Microscope
6. Transmission Electron Microscope
7. Scanning Probe Microscope
8. Scanning Vibrating Electrode setup
9. X-ray Diffractometer
10. Nuclear Magnetic Resonance Spectrometer
11. Electron Spin Resonance Spectrometer
12. Thermo Gravimetric Analysis
13. X-ray Photo Electron Spectrometer

Faculty

Dr. R.H. Suresh Bapu, Shri J. Kennedy

SEMESTER II

ENG(CECRI)2-211	ELECTROCHEMICAL ENGINEERING	L-T-P-C 3-0-0-3

Introduction and Thermodynamic in terms of electrochemical potential-phase equilibrium, chemical and electrochemical potentials, cells with solution of uniform concentration, transport processes in junction regions, cells with a single electrolyte of varying concentration. The Electric potential-the electrostatic potential, intermolecular forces, outer and inner potential, potentials of reference electrode, the electric potential in thermodynamics. Activity coefficients-ionic distributions in dilute solutions, electrical contribution to the free energy, measurement of activity coefficients.

Reference Electrode-criteria of reference electrodes, hydrogen electrode, the calomel electrode and other mercury and mercurous salt electrodes, silver-silver halide electrodes. Potentials of cells with junction- the Nernst equation, types of liquid junctions, cells with liquid junction, potentials across membranes. Structure of the electric double layer-qualitative description of double layers, the Gibbs adsorption isotherm, the Lippmann equation, the diffused part of the double layer. Electrode kinetics, Electrokinetic phenomena, Electro capillary phenomena.

Infinitely dilute solutions-transport laws, conductivity, diffusional potential and transference numbers, conservation of charge, binary electrolyte, supporting electrolyte, multicomponent diffusion by elemination of the electric field. Mobilities and diffusion coefficients. Neutrality and Laplace's equation. Concentrated solutions- liquid junction potentials. Thermal effects-thermal diffusion, heat generation, conservation and transfer. Thermogalvanic cells.

Transport properties- single and multicomponent solutions. Fluid mechanics-stress in a Newtonian fluid, magnitude of electrical forces. Transport in dilutes solutions, simplification for convective transport, the Graetz problem, two-dimensional diffusion layer in laminar forced convection, axisymmetric diffusion layers in forced convection.

Application of potential theory- primary and secondary current distribution. Numerical solution. Effect of migration on limiting currents-Correction factors for limiting currents. Concentration variation of supporting electrolyte, limiting currents for free convection. Concentration overpotential-binary electrolyte, supporting electrolyte. Currents below the limiting current.

Text Books

1. Newman, J., Englewood Cliffs, "Electrochemical Systems", 3rd Edition, Prentice Hall, NJ, 2004.
2. Prentice, G., Englewood Cliffs, "Electrochemical Engineering Principles", Prentice Hall, NJ, 1991

References

1. Rouser, I., Micka, K., & Kimla, A, " Electrochemical Engineering I & II", Elsevier, New York, 1986

Faculty

V. Nandakumar and Dr.Sundar Mayavan

ENG(CECRI)2-212	RESEARCH METHODOLOGY	L-T-P-C 2-0-0-2
Good laboratory practices, Safety in the laboratory, First Aid in the laboratory, Maintenance of laboratory records, Scientific literature management, Communication skills (scientific writing and presentation), Intellectual property management & planning, Ethics in Science, Computer applications and tools, Statistical methods & Data analysis.		
Faculty		
Dr. D. Velayutham and Dr. T. Premkumar		

ENG(CECRI)2-214	ELECTROCHEMICAL ENGINEERING LAB	L-T-P-C 0-0-6-3

Industrial Metal Finishing

Anodizing of Aluminium: To anodize Aluminium and to find out coating ratio and thickness of oxide film. Electroforming of Metal Foil: To electroform Copper/Nickel foil and to find out average thickness and cathode current efficiency. Hull Cell Studies in Electroplating Bath: a) To find out the desirable current density for obtaining good deposits b) To find out the throwing power of the nickel bath with and without additives using Hull Cell. Throwing Power Studies in Electroplating Bath: To find out the throwing power of the given electrolyte using Haring and Blum cell Chromium Plating: To plate chromium and to find out current efficiency and thickness of the deposit.

Corrosion

Corrsion rates measurements by gravimetric method. Soil resistivity and surface potential measurements of concrete slab. Inhibitor evaluation Cathodic protection efficiency by Impressed current Technique.Corrosion rate measurements by Tafel & Linear polarisation methods. Cathodic protection efficiency by sacrificial anode, anode efficiency at various Current densities. Paint formulation and determining of solid contents.

Electrochemicals

To deposit lead dioxide on graphite rod electrode for different durations at different parameters. To prepare potassium chlorate from potassium chloride, and find out the current efficiency and energy consumption. To prepare sodium hypochlorite estimate the available chlorine contents at various time intervals and find out the CE and EC. The preparation of calcium gluoconate by the electro oxidation of glucose. Preparation of succinic acid from Maleic acid.Preparation of P-Aminobenzoic acid from P-Nitro benzoic acid using of Mn^{3+} / Mn^{2+} or Ce^{4+} / Ce^{3+} redox system.

Batteries

Physical methods of characterization, porosity, liquid absorption technique, Charge and Discharge characteristics of Lead Acid and Nickel–Cadmium batteries, Conductivity measurement of Non-aqueous battery electrode, Fuel cell, Impedance Methods Supercapacitors.

Electrochemical Material Science

Chemical deposition of lead sulphide films and measurement of resistivity of the deposits Current voltage characteristics of the given photo-conductive cell in darkness as well as and estimation of photosensitivity. Intensity-photocurrent characteristics of the given photoconductive cell for different bias conditions. Power characteristics of the given silicon at specified intensities. Estimation of the diode parameters of a silicon solar cell. Preparation of CdSe films by the electrochemical route and determination of the cross plane resistivity. Determination of the intensity – photocurrent characteristics of the given silicon cell.

Electrometallurgy

Electro winning of metals like zinc.Electro refining of metals like copper. Electrolytic preparation of metal powders.

Faculty

Dr. R. Sekar, Dr. Rakesh Barik, Dr. D. Velayutham, Dr. D. Vasudevan, Shri S. Ambalavanan, Dr. R.Thangamuthu

SEMESTER III

ENG(CECRI)3-311	ELECTROCHEMICAL REACTION ENGINEERING	L-T-P-C 3-0-0-3

Plugflows and Recycle reactors. Kinetics of electrochemical reactions: multistep electrochemical reactions, multistep electrode processes with mass transport, series and parallel reactions, interaction of chemical reaction, electrochemical reactions involving adsorption, electroanalytical methods.

Multiple electrochemical reactions with interphase mass transport-reaction classification, consecutive reactions, parallel reaction and complex reaction. Potentiostatic and galvanostatic operation of series and parallel electrochemical reactions, reversible reaction. RTD analysis, dispersed plug flow, tank in series model, multiparameter models. Reactor dynamics of isothermal CSTR and PFR.

Simultaneous mass transfer and chemical reaction; mathematical model of interphase mass transport-film model, penetration model, regimes of operation, fast and intermediate chemical reaction. Multiple chemical reaction, multiple electrochemical and chemical reaction. Batch recycles and continuous recycle operation, multiple fluid phases at the electrode surface and in the electrolyte phase. Reactor for multiple phase reactions.

Migration effects on mass transport, influence of migration in the reactor design, current and potential distribution, primary current distribution, current and potential distribution arising from polarization, three dimensional electrodes, diaphragm cell reactor models, energy balance, heat transfer and technical optimizations.

Text Books

1. Scott K, “Electrochemical Reaction Engineering”, Plenum Press, New York, 1991.

2. Goodridge F, Scott K, “Electrochemical Process Engineering”, Plenum Press, New York, 1995

References

1. D.J. Pickett, “Electrochemical Reactor Designs”, Elsevier Scientific Publishing Company, New York, 1979.

Faculty

V. Nandakumar

ENG(CECRI)3-312	DESIGN AND ANALYSIS OF EXPERIMENTS	L-T-P-C 2-0-0-2

Concepts And Terminology

Review of hypothesis testing – P Value, "t" Vs paired "t" test, simple comparative experiment, planning of experiment – steps. Terminology - factors, levels, variables, Design principles – replication, randomization, blocking, confounding, Analysis of variance, sum of squares, degrees of freedom.

Single Factor Experiments

Completely randomized design, Randomized block design, effect of coding the observations, Latin Square design, orthogonal contrasts, comparison of treatment means – Duncan's multiple range test, Newman- Keuel's test, Fisher's LSD test, Tukey's test.

Factorial Experiments

Main and interaction effects, Rules for sum of squares and expected mean square, two and three factor full factorial design, 2k designs with two and three factors, Yate's algorithm, practical applications.

Special Experimental Designs

Blocking and confounding in 2k design, nested design, split – plot design, two level fractional factorial design, fitting regression models, introduction to response surface methods- Central composite design.

Taguchi Techniques

Introduction, Orthogonal designs, data analysis using ANOVA and response graph, parameter design – noise factors, objective functions (S/N ratios), multi-level factor OA designs, applications.

Text Book

1. Douglus C.Montgomery, Design and Analysis of Experiments, John Wiley & Sons,2005

References

1. Angela M.Dean and Daniel Voss, Design and Analysis of Experiments, Springer texts in Statistics, 2000.
2. Philip J.Ross, Taguchi Techniques for Quality Engineering, Prentice Hall, 1989.

Faculty

Dr. C. Naveen Kumar

ELECTIVES

ENG(CECRI) 2-221	MULTIPHASE FLOW	L-T-P-C 3-0-0-3

Multiphase Flow:
Fluid-soild systems, Mobile and stagnant soilds, Flow through porous media, Capillary tube model, Application for flow through packed beds, filters fluidized beds, Soild fluid conveying, setting and sedimentation, Fluid-fluid systems. Flow patterns and flow regimes, Analysis of annular, stratified and bubble flow. Formation of bubbles and drops. Their size distribution and volume distribution.

Flow Classifications:
Two-phase co-current flow of gas and liquid, Gas/Soild, Liquid/Liquid, Upward and downward flow in vertical pipes, Suspensions of sand, gravel, coal etc., and their transport in horizontal pipes, Drag reduction phenomena, Laminar, Turbulent, Creeping flow regimes, Suspension reheology. Residence time distribution studies, Deterministic and stochastic flow system models for chemical reactors, Prevention of circulatory flow, Role of draft tubes and wall baffles, Diffusion model and bubbling bed model for gas interchange and gas mixing, Axial mixing correlations.

Flow-Power Correlations:
Theories of intensity and scale of turbulence, Calculation of circulation velocities and power consumption in agitaed vessels, for Newtonian / non-newtonian fluids, Blending and mixing of phases, Power required for aeration to suspend an immiscible liquid or solids in slurry reactors, Segregation phenomena, Prediction of optimum speed of impeller rotor and Design criteria for scaleup.

Quantative Flow Relationships:
Prediction of holdup and pressure drop or volume fraction, Bubble size in pipe flow, Lockchart-Martinelli parameters, Bubble column and its design aspects, Minimum carryover velocity. Holdup ratios, Pressure drop and transport velocities and their prediction.

Flow In Three-Phase System:
Gas, Solid and Liquid composite slurries in horizontal and vertical pipes, Flow through porous media of composite mixtures, Prediction of holdup, pressure drop and through put velocities in 3-phase system. Design of multiphase contactors involving fluidization, prevaporation, lyophilisation and permeation for Solids, Liquids and Gases, Design and development of software programmes in multiphase flow, simulation in packed and fluidized beds and stirred tank process equipment, Selection of equipment for gaseous, particulate and liquidous effluents of various industries such as scrubbers, Stacks and Chimneys, Absorbers, Combustion devices, Electrostaticprecipitators and filtration/reverse osmosis devices.

References:

1. Govier, G.W. and K.Aziz., - " The Flow of Complex Mixtures in Pipes ", 2nd edition Van Nostrand Reinhold Co., New York, 2008.
2. Wallis, G.B. - " One Dimensional Two phase Flow ", McGraw Hill Book Co., New York, 1969.
3. Brodkey, R.S. - " The Phenomena of Fluid Motions ", Addison - Wesley Publishing Co., New York, 2004.
4. Gad Hestsroni, (Ed.in Chief) - " Handbook of Multi Phase Systems ", Hemisphere Publishing Corporation, Washington and McGraw-Hill Book Company London, 1982.

Faculty

Dr. C. Naveen Kumar

ENG(CECRI)2-222	PROCESS MODELLING AND SIMULATION	L-T-P-C 3-0-0-3

Introduction of modeling, use of mathematical models, fundamental laws-continuity equations, energy equations, equation of motion, transport equations, equation of states, equilibrium, kinetics, Mathematical models of chemical engineering systems-series of isothermal, constant holdup CSTRs, CSTRs with variable hold up gas phase pressurized CSTR non-isothermal CSTR, single component vaporizer, multi component flash drum, reactor with mass transfer, ideal binary distillation column, batch distillation with holdup, pH systems, equilibrium constant models, multi-pass heat exchanger, simultaneous heat and mass transfer in a packed tower series chemical reactions in a tubular reactor, non isothermal reactors.

Definition of the system, lumped-parameter model, the lumped-parameter system requiring simultaneous differential equations, lumped-parameter model of a column tray, unsteady-state operation of the tray. Formulation of a non-dimensional unsteady-state problem, a two-dimensional steady-state heat conduction example, a problem requiring simultaneous partial differential equations, Information flow diagram model for simple hydraulic tank, variable flow hydraulic tank with and without enclosed vessel, mixing vessel with and without reaction, steam jacketed vessel, multiple feeds with and without reaction, steam jacketed vessel continuous flow boiling system, batch distillation, particle age distribution in CSTR, gas flow system hydraulic transients, counter current heat exchanger, pipe gas flow flasher design and tubular reactor.

Time-domain dynamics-linearization, perturbation variables, response of first, second & n-th order ODE, with constant coefficients, steady state technique, Laplace domain dynamics, Iterative convergence methods, Numerical solutions of ODE, solutions by analogue (hybrid) techniques, Numerical simulation of gravity flow tank, non isothermal CSTR, batch reactor.

A systematic approach to changes of variable, example the steam pipe hanger, cooling a sphere, introduction to similarity transforms, similarity transform for one-dimensional unsteady state heat conduction. Physical analogies, the significance physical similarity, generalized, system parameters general types of equation, an example of similar systems, field with distributed sources or sinks, the damped-wave equation, systems in motion. The substantial derivative equations encountered in theory of elasticity, general boundary conditions, laminar-flow tubular reactor, introduction to analog model continuous analogs, network analogs, analogs for lumped-parameter systems.

Large scale systems of models, the molecular approach computational procedure for nonlinear algebraic equations, multiple-effect evaporator problem, steady-state reactor problem, steady-state solution form dynamic equations. Matrix models-simple array models multi component distillation, matrix models of a dynamic distillation system, solution techniques for matrix differential equations, matrix formulation from partial differentials equations an example involving chemical reactions System theory component models, the system graph, linear graph terminology, circuit equations, cut-set vectors, orthogonal relationships maximally selected tree, distillation column.

Text Books:

1. C.L. Smith, R.N. Pike, P.W. Murrells, “Formulation and Optimization of Mathematical Models”, International Text Books Co., Pennsylvania, 1970
2. W.L. Luyben, “Process Modeling and Simulation and Control for Chemical Engineers”, 2nd Edition, Mc Graw Hill International Editions 2,3,4,5,6 and 9, 1990

References

1. GF Roger Franks, Modeling and Simulation in Chemical Engineering, Wiley Inter Science, New York (1972).

Faculty

V. Nandakumar and Dr. G. Sreedhar

ENG(CECRI)2-223	ADVANCED PROCESS DYNAMICS & CONTROL	L-T-P-C 3-0-0-3

Laplace-Domain Dynamics:
Laplace-Domain Analysis of Advanced Control Systems - Cascade Control, Feed forward Control, Open loop-unstable Processes, Processes with Inverse Response, Mode-Based Control.

Frequency-Domain Dynamics and Control:
Frequency-Domain Dynamics - Definition, Basic Theorem, representation, Computer Plotting, Frequency-Domain Analysis of Closedloop Systems - Nyquist Stability Criterion, Closedloop Specifications in the Frequency Domain, Frequency Response of Feedback Controllers, Use of MATLAB of Frequency Response Plots, Capacity-Based Method for Quantifying Controllability.

Multivariable Processes:
Matrix Representation and Analysis - Matrix Representation, Stability, Interaction, Design of Controllers for Multivariable Processes: Problem Definition, Selection of Controlled Variables, Selection of Manipulated Variables, Elimination of Poor Pairings, BLT Tuning, Load Rejection Performance, Model Predictive Control.

Sample-Data Systems:
Sampling, z Transforms, and Stability, Impulse Sampler, Basic Sampling Theorem, z Transformation, Pulse Transfer Functions, Hold Devices, Openloop and Closed loop Systems, Stability in the z plane, Stability Analysis of Sampled-Data Systems: Root Locus Design Methods, Frequency-Domain Design Techniques, Physical Realizability, Minimal-Prototype Design, Process Identification: Fundamental Concepts, Direct Methods, Pulse Testing, Relay Feedback Identification, Least-Squares Methods, Use of the MATLAB Identification Toolbox.

Time Domain Dynamics and Control:
Examples of Process Dynamics and Control, Concepts and terminology. Time Domain Dynamics - Classification and Definition, Linearization and Perturbation Variables, Responses of Simple Linear Systems, Solution using MATLAB. Conventional Control Systems and Hardware - Control Instrumentation, Performance of Feedback Controllers, Controller Tuning. Advanced Control Systems - Ratio Control, Cascade Control, Computed Variable Control, Override Control, Nonlinear and Adaptive Control, valve Position (Optimizing) Control. Feed forward. Control System Design Concepts, Interaction between Steady-State Design and Dynamic Controllability, Plant-wide Control- Series Cascades of units, effect of Recycle of Time Constants, Use of Steady-State Sensitivity Analysis to Screen, Plant-wide Control Structures, Second-Order Reaction Example, and Plant- wide Control Design Procedure.

Text Book:

1. W.L Luyben: “Process modeling, Simulation and Control for Chemical Engineers”, 2nd Edition, McGraw Hill Publishing Company, New York, 1990
2. M.L Luyben W.L Luyben, “Essentials of Process Control”, McGraw Hill Publishing Company, New York, 1997

References

1. George Stephanopolous, “Chemical Process Control - An Introduction to Theory and Practice”, Prentice Hall of India Pvt. Ltd., New Delhi 1990.
2. Emanuel, S.Savas: Computer Control of Industrial Processes, McGraw-Hill, London, 1965.
3. Peter Harriot, “Process Control”, Tata McGraw Hill publishing Co., Ltd., New Delhi, 1977.

Faculty

V. Nandakumar and Dr. Sundar Mayavan

ENG(CECRI)2-224	PROCESS SYNTHESIS AND DESIGN	L-T-P-C 3-0-0-3

Process Creation, Heuristics And Economics

Introduction to process design and process creation, role of process simulation in design, heuristics for process synthesis, introduction to process intensification, cost accounting and capital cost estimation, annual costs, earning and profitability analysis

Heat and Power Integration, Separation Train Synthesis

Minimum utility targets, networks for maximum energy recovery, minmum number of heat exchangers, threshold and optimal approach temperature, superstructure for minimization of annual costs, multiple utilities and heat-integrated distillation trains, heat engines and heat pumps, Criteria for selection of separation methods, Sequencying of ordinary distillation columns for separation of nearly ideal and non-ideal fluid mixtures, Separation systems for gas mixtures, Separation sequencing for solid-fluid systems

Algorithimic Methods

Reactor design and reactor network synthesis, Principles of attainable regions, Locating the separation section with respect to the reactor section, Tradeoffs in processes involving recycle, Optimal reactor conversion, Recycle to extinction, Snowball effect and control of processes involving recycle

Design, Equipment Sizing and Optimization

Review of heat exchanger design, heat transfer coefficients and pressure drop, Design of Shell-Tube heat exchanger, Overview of separation tower design Fenske-Underwood-Gilliland Shortcut method for ordinary distillation, Kemser method for absorption and stripping, Plate efficiency and HETP, Tower diameter, Pressure drop and Weeping, Design of pumps, compressors and expanders

Process Scheduling, Optimization, Plantwide Control

Optimal design and scheduling of batch processes, Design of reactor-Separator Processes, Design of single and multiproduct processing sequence, general formulation and classification of the process optimization problem, Linear and non-linear programming with a single variable, Conditions for Non-linear programming by gradient methods with two or more design variables, Introduction to optimization algorithm, Introduction to plant-wide control.

Text Book

1. W. D. Seider, J. D. Seader and D. R. Lewin, " Product and process design principles", 3nd edition, Wiley - India, New Delhi, 2005

References

1. L. T. Biegler, E. I. Grossmann, A. W. Westerberg, "Systematic methods of chemical process design", Prentice-Hall, Newyork, 1997
2. G. Towler and R. Sinnott, "Chemical Engineering Design", Butterworth Heinemann, Maryland Heights, 2012.

Faculty

Dr. Edward Peter

ENG(CECRI)2-231	CORROSION ENGINEERING	L-T-P-C 3-0-0-3

Basic Aspects of Corrosion

Introduction, classification, economics, emf series, Galvanic series. Corrosion theories : derivation of potential – current relationships of activation controlled and diffusion controlled corrosion processes. Potential – pH diagrams Fe-H_2O system, application and limitations. Passivation-definition, anodic passivation theory of Passivation.

Forms of Corrosion And Concrete Corrosion

Definition, factors and control methods of various forms of corrosion : uniform, galvanic, pitting, inter granular, crevice, dezincification, stress corrosion, corrosion fatigue, hydrogen embrittlement**.**

Factors influencing reinforcement corrosion, corrosion monitoring of concrete structures, corrosion control methods for concrete structures, Repair and rehabilation of concrete structures, special concretes**.**

Atmospheric Corrosion and Protective Coatings

Atmospheric corrosion – classification, factors influencing atmospheric corrosion, temporary corrosion preventive methods ; organic coating – surface preparation, natural, synthetic resin, paint formulation and applications. Paint testing and evaluation.

Immersion Corrosion and Electrochemical Protection

Corrosion in immersed condition : effect of dissolve gases, salts, pH, temperature and flow rates of corrosion; marine corrosion. Underground corrosion – corrosion process in the soil, factors influencing soil corrosion, Biological corrosion definition, mechanism of biological corrosion control of bio corrosion. Electrochemical methods of protection theory of cathodic protection, design of cathodic protection, sacrificial anodes, impressed current anodes, anodic protection. Corrosion inhibitors for acidic, neutral and alkaline media, cooling water system - boiler water system. Corrosion resistant alloys.

Corrosion Monitoring

Laboratory corrosion tests, accelerated chemical tests for studying different forms of corrosion. Electrochemical methods of corrosion rate measurements by Gravimetric, Tafel polarization, linear polarization, cyclic polarization, impedence spectroscopy, harmonics and NDT techniques-ultrasonics, radiography eddy current.

Text Books

1. Zaki Ahmad, “Principles of Corrosion Engineering & Corrosion Control”, Butterworth Heinemann, 2006
2. M.G.Fontana & N.D. Greene, “Corrosion Engineering”, McGraw Hill, New York, 1978

References

1. E.E.Stansbury, R.A.Buchanan, “Fundamentals of electrochemical corrosion”, ASM International, 2000.

Faculty

Dr. S. Sathyanarayanan, Dr. S. Syed Azim, Dr. K. Thangavel, Dr. P. Subramanian, Dr. Rakesh Barik

ENG(CECR)2-232	BIO ELECTROCHEMISTRY	L-T-P-C 3-0-0-3

Ion transport in Biological systems – Mechanism of ion transport – active – passive – Membrane Potential, Membrane action potential – Sodium theory – Nerve conduction – The Donnan Membrane – The Planck membrane – Fixed charge membrane – models of biomembrane – BLMS.

Biological electron transfer reactions, Oxidation – reduction reactions, classes of Electron transferring enzymes – Pyridine linked dehydrogenases – Flavin linked dehydrogenses and oxidases, Iron – Sulphur proteins, Cytochromes, Ubiquinones – The path ways of electron transport – the respiratory chain – inhibitors of electron transport – Energetics of electron transport. Electrochemistry of biological building block molecules.

Nomenclature and structure of the following biological building block molecules, their biological significance and their electrochemistry a) Purines b) pyrimidenes c) Pteridines d) Flavins f) porphyrins g) Pyridine and Pyridine nucleotides

Electrochemistry of redox proteins – Electrical communication between proteins and electrode surfaces through promoters, mediators – Direct electron transfer between protein and Electrode surfaces – Voltammetric methods for studying redox proteins.

Biosensors – Principles – Different Classifications with examples – Details of Construction – Transducers for Biosensors – Different types – Applications of Biosensors. Biological fuel cells – Principles – and Applications.

Text Books:

1. G. Dryhurst, “Electrochemistry of Biological molecules”, Academic Press, New york, 1997

2. Robert Plonsey, “Bioelectric Phenomena”, McGraw-Hill, 1989.

References:

1. Albert L. Lehninger, “Biochemistry”, Kalyani Publishers, Rajindar nagar Ludhiana, 2008.

2. A.E.G. Cass “Biosensors” – A practical approach IRL Press at Oxford University Press, 1990.

Faculty

Dr. V. Ganesh, Dr. J. Mathiyarasu

ENG(CECRI)2-233	PHOTOELECTROCHEMICAL SOLAR CELLS, THIN FILM DEVICES & THEIR APPLICATION	L-T-P-C 3-0-0-3

Photoelectrochemistry, Physics of Semiconductors and pn Junctions, Techniques for Characterization of Semiconductors.

Electrochemical Characterization of Semiconductor, Applications of Photoelectrochemical Cells, Semiconductor Photoelectrochemistry as Theoretical Basis of a Solar Energy Conversion Method.

Thin Film Technology, Thin Film Growth Process, Vapor Deposition Techniques, Solution Deposition Techniques, Thick Film Deposition Techniques, Monitoring and Analytical Techniques, Micro fabrication Techniques. Thin Film in Optics, Antireflection Coatings (AR Coatings), Reflection Coatings, Interference Filters, Thin Film Polarizers, Beam Splitter, Integrated Optics.

Optoelectronic Applications, Photon Detectors, Photovoltic Devices, Applications in Imaging, Electrophotography (Xerography and Electrofax), Thin Film Displays, Information Storage Devices, Amorphous Silicon-Based Devices, Microelectronic Applications, Thin Film Passive Components, Thin Film Active Components, thin Film Integrated Circuits, Microwave Integrated Circuits (MICs), Surface Acoustic Wave (SAW) Devices, Charge-Coupled Devices (CCDs), Thin Film Strain Gauges, Gas Sensors.

Magnetic Thin Film Devices, Magnetic Thin Films, Applications, Quantum Engineering Applications, Basic Concepts, Superconductivity in Thin Films, S-N Transition Devices, Superconductive Tunneling Devices, Thermal Devices, Thermal Imaging Applications, Photothermal Conversion, Surface Engineering Applications, Surface Passivation Applications, Tribological Applications, Decorative Applications.

Text Books:

1. Kasturi Lal Achopra and Inderjeet Kaur, “Thin Film Device Applications”, Plenum Press, New York and Londan, 1983.

2. K.S.V. Santhanam, M. Sharon “Photoelectrochemical solar Cells”, Elsevier science publishers B.V., The Netherlands, 1988.

Faculty

Dr. B. Subramanian, Dr. R. Thangamuthu

ENG(CECRI)2-234	ORGANIC ELECTROCHEMISTRY	L-T-P-C 3-0-0-3

Principles and methods, synthetic and mechanistic aspects of cathodic reactions of organic compounds classified by electrophores, hydrocarbons, halogenated organic compounds, nitro and related compounds, carbonyl compounds, azomethine compounds.

Synthetic and mechanistic aspects of anodic reactions of organic compounds classified by electrophores, anodic oxidation of hydrocarbon, carboxylic acids, nitrogen-containing compounds, oxygen-containing compounds, sulfur-containing compounds, electrochemistry of certain comprehensive classes of compounds, electrolysis of heterocyclic compounds, natural products and pharmaceuticals, biomass, organoelemental and coordination compounds.

Electrode reactions classified by reaction type, reductive coupling, oxidative coupling, cleavages and deprotection, anodic substitution, anodic fluorination.

Stereochemistry of organic electrode processes, amalgam and related reductions, electrogenerated reagents, electrogenerated acids and bases.

Present and future applications, Industrial electroorganic chemistry, electrochemical polymerization, chemically modified electrodes and conducting polymers, photoelectrochemistry, paired electrosynthesis.

Text Book:

1. Henning Laud, Manuel M. Baizer, "Ole Hammerich, Organic Electrochemistry", 4th edition , Marcel Dekker, INC, New York, 2001.

Faculty

Dr. D. Velayutham

ENG(CECRI)2-241	ELECTROCHEMICAL POWER SYSTEMS FOR ELECTRIC VEHICLE	L-T-P-C 3-0-0-3

Introduction to Electric Vehicle Developments. Primary energy sources and alternative fuels for transportation, Electrochemical power sources – Secondary Batteries and fuel cells, Power Density, Energy Density of Batteries, Candidate Batteries for Electric Vehicles

Fundamentals of the lead / acid battery: Basic Thermodynamic Characteristics and Design of Cells, Electrical Characteristics of Cells, SLI (Starter) Batteries, Traction Batteries for Electric Vehicles, Stationary Batteries, Lead Alloys and Grid/Spine Production, Pastes and Pasting, Plate Curing, Plates with Synthesized 4PbO. $PbSO_4$ Paste, Positive Tubular Plate Manufacture, Plate Formation. Lead / acid traction cell and battery design. Characteristics of Traction Cells, Basic Design Principles of the Active Block, Battery Containers and Covers, Cell and Battery assembly. Operation of lead / acid batteries. Self-Discharge and Passivation Phenomena during Shelf-Life, Polarization of the Lead/ Acid Cell, Battery Charging, Battery Discharging, Battery Testing, Processes During Battery Operation, Corrosion of Positive Grids, The Role of Antimony.

Nickel / Iron -Principles of Operation, Battery Design and Construction, Performance Characteristics, Problem Areas and Possible Solutions, Current developmental Programmes, Future Performance of Nickel / Iron Batteries, Cost. Nickel / Zinc- Cell Electrochemistry, Cell Designs and Characteristics, The Nickel Electrode, The Zinc Electrode, Separators for Nickel / Zinc Cells. Metal / Air- Air Electrode, Zinc / Air Battery, Iron / Air Battery, Aluminium / Air Battery, Other Metal / Air Batteries. Zinc / Halogen- Principles of Operation, History, and System Design and Construction, Performance Characteristics, Performance Projections, Projected Production Costs.

Principles of Fuel Cell Operation, Efficiency of Fuel Cells, Materials Considerations in Fuel Cell Systems, Candidate Fuel Cells for Electric Vehicles, Advantages and Disadvantages of Fuel Cells and Secondary Batteries in Electric Vehicle Applications, Acid Systems Direct Methanol / Air systems- Progress in Catalysis, Non-Catalytic aspects, economics. Alkaline systems- Electrochemical and Materials Science Aspects of Fuel Cell Reactions, Engineering and Performance, Vehicular Systems Considerations, Alkaline Fuel Cells as Power Sources for Electric Vehicles. Acid Fuel Cells, Alkaline-Hydrogen Fuel Cells, Battery / fuel-cell Hybrid electric vehicles. Prospects for Electric Vehicles, Different Electric Vehicle Systems, Description of Fuel-Cell Hybrid Systems, Comparison of Fuels.

Laboratory tests of electric vehicle batteries- Battery Characterization Tests, Test Equipment and Facilities, Battery Test Data. Vehicle tests with electric vehicle batteries. Types of Vehicle Tests, Test Cycles, Data Acquisition, Battery Test Data from Vehicle Tests. Future of electric vehicles. Near-term Markets for electric Vehicles, Availability and Price of Liquid Fuels, Improvements in ICEV Technology, Improvements in EV Technology, Economics of EV Purchase and Operation, Broader Considerations.

Reference

1. B.D. McNicol and D.A.J.Rand, “Electrochemical Power Sources for electric vehicle”, 1984

Faculty

Shri S. Amabalavanan, Dr. P. Periyasamy, Dr. I. Arulraj

ENG(CECRI) 2-242	MAINTENANCE – FREE ELECTROCHEMICAL ENERGY CONVERSION & STORAGE SYSTEM	L-T-P-C 3-0-0-3

The Lead-Acid Battery System: The Thermodynamic Situation of Lead-Acid Batteries, Thermodynamic Data, Kinetic Effects, Self-Discharge, Secondary Reactions, Heat Effects, Sulphuric Acid as Active Material, Lead as Current Conducting Material, Copper as Conducting Insert and Grid Material. Valve-regulated Lead-Acid Batteries. Fundamentals, Electrochemical Cell, Equilibrium or Thermodynamic Parameters, Current Flow, Kinetic Parameters, Heating of the Battery, aqueous Electrolyte, its Interactions with the Surrounding Atmosphere. Battery Parameters- Definitions, Cells and Batteries, Capacity, Discharge Parameters, Deep Discharge, Charge Parameters, Internal Resistance, Service Life, Life Expectancy.

Lead-Acid Battery Technology: The Active Material, The Plate Support (The Grid), Connecting Elements (Top Lead), Separators, Containers, Valve Design, The Manufacturing Process, and Lead–Acid Battery Design. Nickel / Cadmium Battery Technology The Active Material, Types of Electrodes Containers, Valve Design, Battery Design.

Loss of Electrolyte And Water: Direct Loss of electrolyte, Formation of Fumes, Water Decomposition in Lead-Acid Batteries, Water Decomposition in Ni / Cd Batteries, Methods to Reduce Water Decomposition. The Internal Oxygen Cycle, Sealed Nickel / Cadmium Batteries, Nickel / Metal Hydride Batteries, Valve–Regulated Lead-Acid Batteries. Battery Technology: Materials for Battery Components, the Active Material

The Nickel / Cadmium Battery System: The Thermodynamic Situation, Kinetic Effects, Self-discharge, Heat Effects, The Electrolyte in Ni / Cd Batteries, Corrosion. The Nickel / Hydrogen And Nickel / Metal Hydride Battery, Nickel / Hydrogen Batteries, Thermodynamic Parameters, Hydrogen-Absorbing Alloys, Low Pressure Nickel / Hydrogen Batteries, Negative Electrodes for Nickel / Metal Hydride Batteries, General Features of the Nickel / Metal Hydride System.

Nickel / Metal Hydride Battery Technology: Negative Electrode Materials, Nickel / Hydride Battery Design, Electric Vehicle Applications. Charging Techniques Charging of Lead-Acid Batteries, Charging of Sealed Nickel / Cadmium Batteries. Battery Monitoring And Battery Management, Smart Batteries. Storage, Ageing And Disposal of Batteries: Storage of Batteries, Ageing of Batteries, Life Expectancy, and Disposal of Used Batteries. Standards And Regulations, National standards, International Standards, European Standards.

Reference:

1. D. Berndt, “Maintenance Free Batteries”, John Wiley & Sons Inc., New York Chichester–Toronto – Brishbane – Singapore.1997

Faculty

S. Ambalavanan and Dr. P. Periyasamy

ENG(CECRI)2-243	FUEL CELLS: SCIENCE & ENGINEERING	L-T-P-C 3-0-0-3

Introduction, History of fuel cells, Operating principles of fuel cells, Fuel cell types, Fuel cell applications, Fuel cell thermodynamics, Fuel cell reaction kinetics

Low Temperature Fuel Cells: *Proton Exchange Membrane Fuel Cells,* Introduction, Working principle, Cell components, Component Development, Performance, Water Management in PEMFC, PEM Fuel Cell Cooling and Air Supply, Reactant Composition, *Alkaline Fuel Cells,* Introduction, Cell components, Performance, Problems and Development, *Direct Methanol Fuel Cells,* Introduction, Anode Reaction and Catalysts, Electrolyte and Fuel Crossover, Cathode Reactions and Catalysts

Medium and High temperature Fuel Cells : Phosphoric Acid Fuel Cells, Molten Carbonate Fuel Cells & Solid Oxide Fuel Cells, Introduction, Cell components, Performance, Problems and Development

Fuels for fuel cells, Introduction, Fossil fuels, Bio-fuels, Fuel Processing, Electrolysers, Biological production of hydrogen, Hydrogen Storage

Fuel Cell Systems, System Processes, Power conditioning, System optimization, Fuel Cell system designs

Text Books

1. Gregor Hoogers, “Fuel Cell Technology Handbook”, CRC Press 2002, Taylor & Francis Group USA.
2. Supramaniam Srinivasan, “Fuel Cells: From Fundamentals to Applications”, Springer, 2006, ISBN 0387354026, 9780387354026
3. Matthew M. Mench, “Fuel Cell Engines”, John Wiley & Sons, 2008, ISBN 0471689580, 9780471689584.
4. James Larminie, Andrew Dicks, “Fuel Cell Systems Explained”, Wiley, 2003, ISBN 0768012597, 9780768012590
5. Frano Barbir, “PEM Fuel Cells Theory and Practice”, Academic Press July 2005.
6. Blomen, Leo, and Michael Mugerwa, “Fuel Cell Systems”, Plenum Press, New York, 1993.
7. Appleby, A. John, “Fuel Cell Handbook”, Van Reinhold Co., New York, 1989.
8. Kordesch, Karl and Günter Simader, “Fuel Cells and Their Applications”, VCH, New York, 1996.

Reference

1. Wolf Vielstich (Editor), Arnold Lamm (Editor), Hubert A. Gasteiger (Editor), “Handbook of Fuel Cells: Fundamentals, Technology, Applications”, 4-Volume Set ISBN: 978-0-471-49926-8

Faculty

Dr. P. Sridhar, Dr.Santhosh Kumar D. Butt, Dr. A.K. Sahu

ENG(CECRI)2-244	ELECTROCHEMICAL SUPERCAPACITORS	L-T-P-C 3-0-0-3

Similarities and Differences between Supercapacitors and Batteries: Faradaic and Non-Faradaic Processes, Types of Capacitors and Batteries, Differences of Densities of Charge Storage in Capacitors and Batteries, Charge and Discharge Behavior of Electrochemical Capacitors and Battery Cells. Energetic of Electrode Processes, Double-Layer Effects in Electrode Kinetics, Electrical Response Functions Characterizing Capacitative Behavior of Electrodes. Electrostatics Involved in Treatment of Double Layers and Ions at Capacitor Electrode Interphases. Energy and Entropy Stored by a capacitor.

Behavior of Dielectrics in Capacitors and Theories of Dielectric Polarization. The Double Layer at Capacitor Electrode Interfaces. Models and Structures of the Double Layer, Two-Dimensional Density of Charges in the Double Layer, Ionic Charge Density and Interionic Distances on the Solution Side of the Double Layer.

Theoretical Treatments of Pseudocapacitance ($C\varphi$), Redox and Intercalation Pseudocapacitances, Pseudocapacitance Associated with Specific Adsorption of Anions and the Phenomenon of Partial Charge Transfer, Pseudocapacitance Behavior at High-Area Carbon Materials, Procedures for Distinguishing Pseudocapacitance ($C\varphi$) from Double-Layer Capacitance (C_{dl}). The Electrochemical Behavior of Ruthenium Oxide (RuO_2) Films as a Material for Electrochemical Capacitors- The Transition From Monolayer to Multilayer Electrochemical Formation of RuO_2, States and Chemical Constitution of Electrochemically and Thermo chemically formed RuO_2 and IrO_2 Electrodes. Capacitance Behavior of Films of Conducting, Electrochemically Reactive Polymers: Electrochemical Behavior, Behavior in Relation to Pseudocapacitance.

The Electrolyte Factor in Supercapacitor design and Performance: Conductivity, Ion Pairing and Solvation, Electrolyte Conductance and Dissociation, Relation of Electrolyte Conductivity to Electrohemically Available Surface Area and Power Performance of Porous Electrode Supercapacitors, The Ion Salvation Factor, Electrochemical Behavior at Porous Electrodes: Real Area and Double-Layer Capacitance, Energy and Power Density of Electrical Energy Storage Devices: Ragone Plots of Power Density vs. Energy Density, Energy and Power Density, and their Relationship, Power Limitation Due to Concentration Polarization, Relation between C-Rate Specification and Power Density, Optimization of Energy and Power Density.

Impedance Behavior of Various Circuits and Modeling of Double-Layer Capacitor, Frequency Response, Impedance Behavior of a Redox Pseudocapacitance, Self–Discharge of Electrochemical Capacitors in Relation to that at Batteries: Practical Phenomenology of Self-Discharge by Activation-Controlled Faradaic Processes, Self-Discharge of Double-Layer-Type Supercapacitor Devices, Redistribution of Charge in Nonuniform Charged Porous Electrodes, Self-Discharge of a Pseudocapacitance, Carbon Capacitors and Carbon Fiber Electrodes, Self-Discharge and Potential Recovery Behavior at an RuO_2 Electrode, Self-Discharge in a Stack. Practical Aspects of Preparation and Evaluation of Electrochemical Capacitors: Preparation of Electrodes for Small Aqueous Carbon-Based Capacitors for Testing Materials, Preparation of RuO_x Capacitor, Capacitors with a polymer Electrolyte Membrane. Technology of Electrochemical Capacitors, Capacitor- Battery Hybrid Application for Electric Vehicle Drive Systems, Market Aspects, Energy Storage by High-Voltage electrostatic Capacitors.

Reference:

1. B.E. Conway, “Electrochemical Supercapacitors”, Fellow of the Royal society of Canada University of Ottawa, Ontario, Canada,1999.

Faculty

Dr. M.V.T.Dhananjeyan, Dr. M. Ganesan, Dr. P. Periyasamy and Dr. C. Sivakumar