CURRICULUM FOR THE MSc POLYMER & PROCESS ENGINEERING

Department Requirements (30 Credit Hours)

1.1 Departmental Core – 12 Credit Hours

PPE-501	Polymer Rheology and Viscoelasticity	3(3,0)
PPE-502 & PPE-502L	Macromolecule Design and Characterization	3(2,1)
PPE-503	Advanced Separation Processes	3(3,0)
PPE-504	Optimization and Process Design	3(3,0)

1.2 Departmental Electives – 12 Credit Hours

PPE-505 & PPE-505L	Polymer Reactor Design	3(2,1)
PPE-506 & PPE-506L	Modeling and Simulation in Polymer Processing	3(2,1)
PPE-507 & PPE-507L	Elastomeric Materials & Processes	3(2,1)
PPE-508	Advanced Polymer Composites	3(3,0)
PPE-509 & PPE-509L	Polymeric Membrane Design and Applications	3(2,1)
PPE-510 & PPE-510L	Compounding Principles and Polymer Blending	3(2,1)
PPE-511 & PPE-511L	Advanced Functional Polymers	3(2,1)
PPE-512	Polymer Coatings and Applications	3(3,0)
PPE-513	Statistical Techniques for Data Analysis	3(3,0)
PPE-514	Advanced Process Control	3(3,0)

1.3 Thesis – 6 Credit Hours

PPE-601	Master's Thesis	6(0,6)

Last edited: Dr Shafiq Irfan (1-July-2015)

DEPARTMENTAL CORE

PPE-501 POLYMER RHEOLOGY AND VISCOELASTICITY

Credit Hours: 3 (Theory = 3)
Contact Hours: 3 (Theory = 3)

1. Introduction to rheology and viscoelasticity
2. Viscosity: *Background, effects of shear rate, temperature, pressure, definition of Newtonian behavior, the shear-thinning and shear thickening non-Newtonian liquid, time effects in non-Newtonian liquid, viscometers for measuring shear viscosity: classification, industrial shop-floor instruments, rotational instruments, the narrow-gap concentric-cylinder, the wide-gap concentric-cylinder viscometer, cylinder rotating in a large volume of liquid, the cone-and-plate viscometer, the parallel-plate viscometer, capillary viscometer, slit viscometer, on-line measurements*
3. Linear Viscoelasticity: *Introduction, the meaning and consequences of linearity, the Kelvin and Maxwell, the relaxation, oscillatory shear, relationships between functions of linear viscoelasticity, methods of measurement, static and dynamic*
4. Normal Stresses: *The nature and origin of normal, typical behavior of N1 and N2, methods of measuring the normal, relationship between viscometric functions and linear viscoelastic functions*
5. Extensional Viscosity: *Introduction and importance of extensional, theoretical considerations, experimental methods and results for stretching flows, high extensional viscosity behavior*
6. Rheology of Polymeric Liquids: *Introduction and general behavior, effect of temperature, molecular weight and concentration, polymer, liquid crystal polymers, molecular theories of polymer rheology, the method of reduced, empirical relations between rheological functions, practical applications of rheology*
7. Rheology of Suspensions: *The general form of the viscosity curve for suspensions, summary of the forces acting on particles suspended in a liquid, rest structures, flow-induced structures, the viscosity of suspensions of solid particles in Newtonian liquids, the colloidal contribution to viscosity, viscoelastic properties of suspension, suspensions of deformable particles*
8. Theoretical Rheology: *Introduction to theoretical rheology, basic principles of continuum mechanics, successful applications of the formulation principles, some general constitutive equations*

Textbook:

1. Barnes, H.A., Hutton, J.F., Walters, K., *An Introduction to Rheology*, Elsevier Science Publishers B.V. The Netherlands, 1993

Reference book:

2. Barnes, H. A., *A Handbook of Elementary Rheology*, The University of Wales UK, 2000

PPE-502 MACROMOLECULE DESIGN AND CHARACTERIZATION

Credit Hours: 3 (Theory = 2, Laboratory = 1)
Contact Hours: 5 (Theory = 2, Laboratory = 3)

Part 1: Polymer Modification

1. Classification and nomenclature
2. Polymer Reactions and catalysis
3. Morphological and macromolecular considerations
4. Chemical modification

Part 2: Characterization Techniques

5. Introduction to polymer characterization
6. Fourier transform infrared spectroscopy and Raman spectroscopy
7. Thermal characterization (DSC and TGA)
8. Thermomechanical and dynamic mechanical characterization of polymers
9. Nuclear magnetic resonance of polymeric materials
10. Size exclusion using light scattering
11. Morphological characterization using optical microscope, SEM, TEM

Textbooks:

1. Dietrich Braun, Harald Cherdron, Matthias Rehahn, Helmut Ritter, Brigitte Voit, *Polymer Synthesis: Theory and Practice: Fundamentals, Methods, Experiments*, Fifth Edition, Springer, 2013 (ISBN-13: 978-3642289798)
2. H. Lobo, J. V. Bonilla, *Handbook of Plastic Analysis*, 2003, Marcel Decker Inc., (ISBN 0-8247-0708-7)

LABORATORY:

The laboratory section involves the hand-on training on the characterization techniques including:

(a) Differential scanning calorimetry (DSC)
(b) Thermal gravimetric analyzer (TGA)
(c) Fourier transform infra-red (FTIR) spectroscopy
(d) UV spectroscopy

Last edited: Dr Shafiq Irfan (1-July-2015)

PPE-503 ADVANCED SEPARATION PROCESSES

Credit Hours: 3 (Theory = 3)
Contact Hours: 3 (Theory = 3)

1. Selection and scaling: *Selection of conventional separation process, scaling of conventional separation process*
2. Transport in membranes: *Porous membranes, bulk flow, liquid diffusion in pores, gas diffusion, nonporous membranes, solution-diffusion for liquid mixtures, solution-diffusion for gas mixtures, module flow patterns, external mass-transfer resistances, concentration polarization and fouling, liquid membranes, gas permeation through polymeric membranes*
3. Design of novel separation processes: *Reverse osmosis, ultra filtration, dialysis, electro dialysis, donnan dialysis, parametric pumping and pressure swing adsorption separation processes*

Textbook:

1. Seader, J.D. and Henley, E.J., *Separation process Principles*, Second Edition, John Wiley & Sons, 2006

Reference Books:

2. Ronald W. Rousseau (Ed.), *Handbook of Separation Process* Technology, John Wiley & Sons, 1987
3. Fouad M . Khoury, *Multistage Separation Processes*, Third Edition, CRC Press, 2005

PPE-504 OPTIMIZATION AND PROCESS DESIGN

Credit Hours: 3 (Theory = 3)
Contact Hours: 3 (Theory = 3)

1. The nature and organization of optimization problems: *What Optimization Is All About, Why Optimize? Scope and Hierarchy of Optimization, Examples of applications of Optimization, The Essential Features of Optimization Problems, General Procedure for Solving Optimization Problems, Obstacles to Optimization.*
2. Developing Models for Optimization: *Classification of Models, How to Build a Model, Selecting Functions to Fit Empirical Data, Factorial Experimental Designs, Degrees of Freedom, Examples of Inequality and Equality Constraints in Models.*
3. Formulation of the Objective Function: *Economic Objective Functions, The Time Value of Money in Objective Functions, Measures of Profitability*
4. Basic Concepts of Optimization: *Continuity of Functions, NLP Problem Statement, Convexity and Its Applications, Interpretation of the Objective Function in Terms of its Quadratic Approximation, Necessary and Sufficient Conditions for an Extremum of an Unconstrained Function*
5. Unconstrained Multivariable Optimization: *Steepest Descent, Newton's Method, Quasi-Newton Methods*
6. Linear Programming (LP) and Applications: *Basic Linear Programming Definitions and Results, Simplex Algorithm, Linear Mixed Integer Programs*
7. Nonlinear Programming with Constraints: *First-Order Necessary Conditions for a Local Extremum, Penalty, Barrier, and Augmented Lagrangian Methods, Kuhn Tucker Condition*
8. Mixed-Integer Programming: *Branch-and-Bound Method*
9. Applications of Optimization: *Heat Transfer and Energy Conservation, Separation Processes*
10. Process Design: *Review of process design, basic concepts of process engineering and techniques, generation, Process Operability & Flexibility, Feasible Operations in Process Design, Problems in Flexibility, Flexibility Test & Flexibility Index, Algorithm for flexibility analysis, analysis and evaluation of alternatives, strategy of process synthesis, technical forecasting, concepts and application of reliability*

Textbooks:

1. T. F. Edgar and D. M. Himmelblau, *Optimization of Chemical Processes*, 2nd Ed., McGraw-Hill, 2001
2. L. T. Biegler, I. E. Grossmann, and A. W. Westerberg, *Systematic Methods of Chemical Process Design*, Prentice-Hall, 1997

Reference Books:

3. C. A. Floudas, *Nonlinear and Mixed-Integer Optimization: Fundamentals and Applications*, Oxford University Press, 1995
4. G. L. Nemhauser and L. A. Wosley, *Integer and Combinatorial Optimisation*, Wiley, New York, 1989

DEPARTMENTAL ELECTIVES

PPE-505 POLYMER REACTOR DESIGN

Credit Hours: 3 (Theory = 2, Laboratory = 1)
Contact Hours: 5 (Theory = 2, Laboratory = 3)

SECTION 1: POLYMERIZATION

1. Chain and step polymerization reactions,
2. Radical polymerization
3. Anionic polymerization
4. Coordination polymerization
5. Cationic polymerization
6. Living polymerization processes
7. Step polymerization processes
8. Thermodynamics of step and addition polymerization reactions
9. Comparison of chain and step addition polymerizations reactions

SECTION 2: POLYMERIZATION REACTOR DESIGN

1. Factors in reactor design
2. Choice of phases
3. Choice of reactor types
4. Separation and recovery systems
5. Design fundamentals

SECTION 3: CONTROL OF POLYMERIZATION REACTORS

1. Characterization of the control problem
2. Classical polymerization reaction control problems
3. Control of reaction rates and of reactor temperature
4. Control of monomer conversion and polymer production
5. Control of molecular weight averages and MWDs
6. Control of copolymer composition
7. Control of particle size and PSDs
8. Control of other reaction parameters
9. On-line monitoring

Textbooks

1. Jose Asua (Editor), *Polymer Reaction Engineering*, Wiley-Blackwell, 2007 (ISBN: 978-1405144421)
2. C. McGreavy, *Polymer Reactor Engineering*, Springer Science+Business Media Dordrecht, 1994

LABORATORY:

(a) Extensive literature review the polymer reaction kinetics and polymer reactor design
(b) Experimental studies on the kinetic of polymerization reactions

PPE-506 MODELING AND SIMULATION IN POLYMER PROCESSING

Credit Hours: 3 (Theory = 2, Laboratory = 1)
Contact Hours: 5 (Theory = 2, Laboratory = 3)

PART ONE: INTRODUCTION

1. Transport phenomena in polymer processing
2. Simple models in polymer processing: *Pressure driven flow of a Newtonian fluid through a slit, flow of a power law fluid in a straight circular tube (Hagen-Poiseuille, equation), flow of a power law fluid in a slightly tapered tube, volumetric flow rate of a power law fluid in axial annular flow, radial flow between two parallel discs − Newtonian model, The Hele-Shaw model, cooling or heating in polymer processing*

PART TWO: ANALYSES BASED ON ANALYTICAL SOLUTIONS

3. Single screw extrusion−isothermal flow problems
4. Extrusion dies−isothermal flow problems
5. Processes that involve membrane stretching
6. Calendering − isothermal flow problems
7. Coating processes
8. Mixing − isothermal flow problems
9. Injection molding − isothermal flow problems
10. Non-isothermal flows
11. Melting and solidification
12. Curing reactions during processing

PART THREE: ANALYSES BASED ON NUMERICAL SOLUTIONS

13. Introduction to numerical analysis
14. Steady-state problems via finite difference method
15. Finite-element methods in polymer processing

PART FOUR: COMPUTER-AIDED POLYMER PROCESSING SIMULATION

16. Injection molding simulation software
17. Extrusion-based simulation software

Textbooks:

1. Tim A. Osswald, Juan P. Hernández-Ortiz, *Polymer Processing: Modeling and Simulation*, Hanser, 2006 (ISBN-13: 978-1569903988)

Reference Books:

2. Zehev Tadmor, Costas G. Gogos, *Principles of Polymer Processing*, Second Edition, Wiley-Interscience, 2006 (ISBN-13: 978-0471387701)
3. Donald G. Baird, Dimitris I. Collias, *Polymer Processing: Principles and Design*, Second Edition, Wiley, 2014 (ISBN-13: 978-0470930588)

LABORATORY:

(a) Extensive literature review the modelling approaches towards polymer processing operations.
(b) Software-based mathematical modelling of polymer processing operations using Matlab.
(c) Simulation of injection molding process using commercial software packages like Moldflow®

PPE-507 ELASTOMERIC MATERIALS & PROCESSES

Credit Hours: 3 (Theory = 2, Laboratory = 1)
Contact Hours: 5 (Theory = 2, Laboratory = 3)

SECTION I ELASTOMERIC MATERIALS

1. Natural Rubber**:** *Brief history of rubbers, introduction to natural rubber, production and cultivation of natural rubber, grades of natural rubber, modified forms of natural rubber, properties and vulcanization of natural rubber application of natural rubber.*
2. Synthetic Elastomers: *Styrene butadiene rubber (SBR), polybutadiene rubber (BR), polyisoprene (IR), speciality Elastomers: polychloroprene (CR), acrylonitrile butadiene rubber (NBR), butyl rubber (IIR), ethylene propylene rubber (EPM, EPDM), silicone rubber (MQ), polysufide rubber, chlorosulphonated polyethylene (CSM), acrylic rubber (ACM), florocarbon rubber (FKM), urethane rubber*
3. Thermoplastic Elastomers**:** *Introduction, Segmental block copolymers TPEs, Dynamically vulcanized thermoplastic elastomer blends.*

SECTION II COMPUNDING INGREDIENTS

4. Fillers for Rubber: *Carbon black, and non-black fillers*
5. General Compounding and Vulcanisation**:** *Curing agent, accelerators, activators, antidegradants, antioxidants, antiozonants, waxes, processing aids, homoginizers, tackifiers, peptizers, lubricants, plasticizers, resins, retarders, blowing agent*

SECTION III ELASTOMER PROCESSING

6. Processing and Engineering with Elastomers: *Introduction to mixing, Mechanism of mixing, Rheology of mixing, Types of mixing processes, Outline design factors f different products, Durability aspects, Failure, Life Assessment, Design equations for engineering components, Fatigue and environmental factors of elastomeric components.*

SECTION IV TESTING OF ELASTOMERS

7. Testing of Elastomers: *General tests, Processability testing, Mechanical testing*

Textbook

1. J. R. White, S. K. De, Rubber Technologist's Handbook, Rapra Technology Limited, 2001 (ISBN 1-85957-262-6)

LABORATORY:

(a) Extensive literature review rubber compounding techniques
(b) Experimental studies on the rubber compounding/curing coupled with characterization of the resultant compounds

PPE-508 ADVANCED POLYMER COMPOSITES

Credit Hours: 3 (Theory = 3)
Contact Hours: 3 (Theory = 3)

1. General introduction: *Types of composite materials, design of composite materials, the concept of load transfer*
2. Fibers and matrices: *Reinforcement, the strength of reinforcements, matrices*
3. Fiber architecture: *General considerations, long fibers, short fibers, voids*
4. Elastic deformation of long fiber composites: *Axial stiffness, transvers stiffness, shear stiffness, Poisson's contraction effects*
5. Elastic deformation of laminates: *Elastic deformation of anisotropic materials, off-axis elastic constants of laminae, elastic deformation of laminates, stresses and distortions*
6. Stresses and strains in short fiber composites: *Shear lag model, Eshelby model*
7. Interface region: *Bonding mechanisms, experimental measurement of bond strength, control of bond strength*
8. Strength of composites: *Failure modes of long fiber composites, failure of laminates under off axis load, strength of laminates, failure of tubes under internal pressure, composite failure criteria, 10% rule, maximum stress, maximum strain, Tsai-Hill, Tsai-Wu, Hashin, Puck's, Hart Smith criteria for strength prediction*
9. Toughness of composites: *Fracture mechanics, contributions to work of fracture, sub-critical crack growth*
10. Thermal behavior of composites: *Thermal expansion and thermal stresses, Creep, Thermal conduction*
11. Fabrication: *Fundamentals, bag-molding process, compression molding, pultrusion, filament winding, liquid composite molding process, other manufacturing processes, manufacturing processes for thermoplastic matrix composites, quality inspection methods*
12. Polymer nanocomposites: *Nanoclay, carbon nanofibers, carbon nanotubes, structure, production of carbon nanotubes, functionalization of carbon nanotubes, mechanical properties of carbon nanotubes, carbon nanotube–polymer composites, properties of carbon nanotube–polymer composites*
13. Recycling of polymer composites material selection
14. Applications: *Minesweeper hull, sheet processing rolls, helicopter rotor blade, golf driving club, racing bicycle, Diesel engine piston, microelectronics housing, gas turbine combustor can, aircraft brakes, Latest research trends*

Textbooks:

1. D. Hull & T.W. Clyne, *An Introduction to Composite Materials*, 2nd Ed., Cambridge University Press, 1997
2. J.M. Hodgkinson, *Mechanical Testing of Advanced Fibre Composites*, Woodhead Publishing Limited, CRC Press, 2000

Reference Book:

3. P.K. Mallick, *Fiber Reinforced Composites: Materials, Manufacturing, and Design*, 3rd Ed., CRC Press, 2007

PPE-509 POLYMERIC MEMBRANE DESIGN & APPLICATIONS

Credit Hours: 3 (Theory = 2, Laboratory = 1)
Contact Hours: 5 (Theory = 2, Laboratory = 3)

THEORY:

1. Introduction to membranes and various membranes processes
2. Membrane transport theory: *The solution diffusion model, structure-permeability relationship, pore-flow membranes*
3. Membranes preparation and modules fabrication: *Isotropic membranes, anisotropic membranes, phase separation membranes, interfacial polymerization membranes, solution-coated composite membranes, specialty methods for anisotropic membranes, repairing membrane defects, hollow fiber membranes, membrane modules and their selection*
4. Reverse osmosis: *Theoretical background, membranes and materials, reverse osmosis membrane categories, membrane selectivity, membrane modules, membrane fouling control, applications of ro processes*
5. Pervaporation: *Introduction and theoretical background, membrane materials and modules, dehydration membranes, organic/water separation membranes, organic/organic separation membranes, membrane modules, applications to solvent dehydration, separation of dissolved organics from water and separation of organic mixtures*
6. Gas separation: *Introduction and theoretical background, polymer GS membranes, non-polymer GS membranes, membrane modules, process design and pressure ratio, stage-cut, multistep, multistage and recycle system designs, applications of GS to hydrogen separations, oxygen/nitrogen separation, natural gas separations, carbon dioxide separation*

Textbooks:

1. Baker, Richard W., *Membrane Technology and Applications*, 3rd edition, John Wiley and Sons Ltd., 2012
2. Porter, Mark C. Ed., *Handbook of Industrial Membrane Technology*, Noyes Publications US, 1990

LABORATORY:

Review on a particular membranes process/type, design, synthesis and selection of membranes, chemical and structural characterization of synthesized membrane, performance evaluation through reverse osmosis, pervaporation, nano-filtration, electrochemical transport etc

PPE-510 COMPOUNDING PRINCIPLES & POLYMER BLENDING

Credit Hours: 3 (Theory = 2, Laboratory = 1)
Contact Hours: 5 (Theory = 2, Laboratory = 3)

SECTION I: POLYMER COMPOUNDING

1. Introduction to compounding additives
2. Pre-compounding operations
3. Compounder types: *Screw nomenclature and geometries, Batch types, Single screw extruder, Counter-rotating twin screw extruder, Co-rotating twin screw extruder, other compounding equipment*

SECTION II: POLYMER BLENDING

4. Introduction to polymer blends and alloys
5. Polymer blends –industrial aspect
6. Thermodynamics of polymer blends
7. Preparation principles and processing prospects of polymer blends
8. Interpenetrating polymer blends
9. High performance engineering polymer blends
10. Plastic blending processes
11. Industrial blends and their processing
12. Barrier polymers and blends for packaging
13. Commercialized polymer blends
14. Blends of engineering plastics
15. Polymer blends in footwear

Textbooks:

1. Robert H. Wildi, Christian Maier, *Understanding Compounding*, Hanser Gardner Pubns., 1998
2. R. P. Singh,C.K. Das, S.K. Mustafi, *Polymer Blends and Alloys*, Asian Books Private Limited, 2002

LABORATORY:

(a) Extensive literature review polymer compounding ingredients and techniques
(b) Experimental studies on the polymer compounds and blends coupled with characterization of the resultant compounds/blends

PPE-511 ADVANCED FUNCTIONAL POLYMERS

Credit Hours: 3 (Theory = 2, Laboratory = 1)
Contact Hours: 5 (Theory = 2, Laboratory = 3)

SECTION-I INTRODUCTION AND TYPES OF FUNCTIONAL POLYMER

(a) Introduction to smart polymers and their applications: *Types of smart polymer, applications of smart polymers*
(b) Intrinsically conducting polymers (ICPs)

(c) Temperature-responsive polymers: *Basic principles of temperature-responsive polymers in aqueous solution, Key types of temperature-responsive polymers in aqueous solution, selected applications of thermo-responsive polymers*
(d) pH-responsive polymers: *Key types and properties of pH-responsive polymers, synthesis of pH-responsive polymers, applications*
(e) Photo-responsive polymers: *Chromophores and their light-induced molecular response, Key types and properties of photo-responsive polymers, applications*
(f) Magnetically responsive polymer gels and elastomers: *Preparation of magnetically responsive polymer gels and elastomeric materials, magnetic properties of filler-loaded polymers, Elastic behavior of magnetic gels and elastomers*
(g) Enzyme-responsive polymers: *Key types and properties of enzyme-responsive polymers, preparation of enzyme-responsive polymers, Characterization of enzyme-responsive polymers, applications*
(h) Shape memory polymers: *Characterizing shape memory effects in polymeric materials, classifying shape memory polymers, main applications*
(i) Self-healing polymer systems: *Types of self-healing, self-healing and recovery of functionality in materials, applications*

SECTION-II APPLICATIONS OF FUNCTIONAL POLYMER

(a) Smart instructive polymer substrates for tissue engineering
(b) The use of smart polymers in medical devices for minimally invasive surgery, diagnosis and other applications
(c) Smart polymers for bio-separation and other biotechnology applications
(d) Smart polymers for textile applications
(e) Biopolymers for food packaging applications
(f) Smart polymers for optical data storage

SECTION-III RECENT ADVANCES

(a) A review of latest research papers in the field of functional polymers

Textbooks:

1. Liming Dai, *Intelligent Macromolecules for Smart Devices: From Materials Synthesis to Device Applications*, Springer, 2004 (ISBN-13: 978-1852335106)
2. Maria Rosa Aguilar and Julio San Roman, *Smart Polymer and their Applications*, Woodhead Publishing, 2014 (ISBN-13: 978-0857096951)

LABORATORY:

(a) Extensive literature review on advances in functional polymers
(b) Synthesis and characterization of functional polymers for electro-active polymer based applications

PPE-512 POLYMER COATINGS AND APPLICATIONS

Credit Hours: 3 (Theory = 3)
Contact Hours: 3 (Theory = 3)

1. Economics and the environment: The role of coatings
2. The rheology of coatings: *Introduction to rheology, rheological measurements, rheological processes associated with coatings, low VOC coatings – flow problems and solutions*
3. Film formation: *Thermoplastic coatings, solutions of crosslinking polymers, consequences of vitrification, solvent-less crosslinking systems, disperse phase polymer systems*
4. Performance properties of coatings: *Mechanical performance, ageing processes and the retention of properties, chemical exposure*
5. Binders for conventional coatings: *Binders as polymers, polymers as binders, thermoplastic binders, reactive binders, crosslinking chemistry – binding the binders, polymer blends*
6. Binders for high solids and solvent-free coatings
7. Binders for waterborne coatings: *Colloidal and non-colloidal systems, emulsion polymerisation, practical aspects of emulsion polymerisation, outlook for latex-based coatings, pseudo-latexes, dispersion polymerisation, water reducible systems, hydrosols, micro-gel, crosslinking of water-borne*
8. Coatings components beyond binders: *Pigments, solvents, additives*
9. The science and art of paint formulation for performance, application, compliance and economy
10. Application and applications: *Substrates and their preparation, the application of coatings, markets for coatings*

Textbook:

1. Alastair Marrion Ed., *The Chemistry and Physics of Coatings*, Second Edition, The Royal Society of Chemistry, 2004

Reference Book:

2. Arthur A. Tracton Ed., *Coatings Technology: Fundamentals, Testing, and Processing Techniques*, CRC Press Taylor & Francis Group, 2007

PPE-512 STATISTICAL TECHNIQUES FOR DATA ANALYSIS

Credit Hours: 3 (Theory = 3)
Contact Hours: 3 (Theory = 3)

1. Introduction to statistical data: *Types of data, variability, populations and samples, importance of reliability, metrology, computer assisted statistical analyses*
2. Obtaining meaningful data: *The experimental method, data quality indicators, data quality objectives, systematic measurements, quality assurance,*
3. General principles: *Kinds of statistics, decisions, error and uncertainty, kinds of data, accuracy, precision, and bias, statistical control, data descriptors, distributions, tests for normality, basic requirements for statistical analysis validity*
4. Statistical calculations: *The mean, variance, and standard deviation, degrees of freedom, using duplicate measurements to estimate a standard deviation, using the range to estimate the standard deviation, pooled statistical estimates, simple analysis of variance, log normal statistics, minimum reporting statistics, computations*
5. Data analysis techniques: *One sample topics, means, confidence intervals for one sample, standard deviations, confidence intervals for one sample, statistical tolerance intervals, combining confidence intervals and tolerance intervals; two sample topics, means, do two means differ significantly, standard deviations, propagation of error in a derived or calculated value*
6. Managing Sets of Data: *Outliers, combining data sets, statistics of inter-laboratory collaborative testing, random numbers*
7. Presenting data: *Tables, charts, graphs, mathematical expressions, fitting data*
8. Proportions, survival data and time series data: *Proportions, two-sided confidence intervals for one sample, one-sided confidence intervals for one sample, sample sizes for proportions-one sample, two-sided confidence intervals for two samples, chi-square tests of association, one-sided confidence intervals for two samples, sample sizes for proportions-two samples; Survival data; Time series data*
9. Linear regression

Textbook:

1. John K. Taylor, Cheryl Cihon, *Statistical Techniques for Data Analysis*, Second Edition, Chapman & Hall/CRC, 2004

PPE-514 ADVANCED PROCESS CONTROL

Credit Hours: 3 (Theory = 3)
Contact Hours: 3 (Theory = 3)

1. Overview of the differential equations and their solution using Laplace transformation, First and higher order systems, Feedback control system, Stability of the control system, PID controller design and tuning
2. Frequency response analysis and Control system design
3. Feedforward and Ratio control
4. Cascade control, Time-Delay compensation, Inferential control, Selective control/override systems, Non-linear control systems, Adaptive control systems
5. Digital Sampling, Filtering and Control: Sampling and Signal processing, Z-transform analysis, Tuning of digital PID controllers, Direct synthesis of design of digital controllers,
6. Multiloop and Multivariable control: Process interactions and control loop interactions, pairing of controlled and manipulated variables, Singular value analysis, Tuning of multiloop PID controllers, Decoupling of multivariable control strategies, Strategies for reducing control loop interactions
7. Model Predictive Control (MPC): Overview, Predictions for SISO and MIMO models, MPC calculations, Set-point calculations, Selection of Design and Tuning parameters, Implementation of MPC
8. Process Monitoring: Traditional techniques, Quality control charts, Statistical Process control (SPC), Multivariate statistical techniques, Control performance monitoring
9. Introduction to Plantwide Control: Plantwide control issues, Hypothetical plant for plantwide control studies, Internal Feedback of Material and Energy, Interaction of plant design and control system design
10. Digital Process Control Systems: Hardware and Software: Distributed Digital Control Systems, Analog and digital signals and data transfer, Microprocessors and digital hardware, Software organization

Textbook

1. Dale E. Seborg, Duncan A. Mellichamp, Thomas F. Edgar, *Process Dynamics and Control*, Third Edition, Wiley, 2010 (ISBN-13: 978-0470128671)

Reference Books:

2. Smith, C. L., Advanced Process Control: Beyond Single-loop Control, John Wiley & Sons Inc., 2010
3. Stephanopoulos, G., Chemical Process Control: An Introduction to Theory and Practice, P T R Prentice Hall,

THESIS – 6 Credit Hours

PPE-601 MASTER'S THESIS

Supervised original Research in specific area of Polymer & Process Engineering